THE
POPULAR SCIENCE
MONTHLY

MARCH, 1908

AMERICA'S INTELLECTUAL PRODUCT[1]

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IT may not be out of place for one who is unaccustomed to the constraint of reading from a pulpit to fortify himself with a text. From an excellent source I select the following: "Behold, a sower went forth to sow; and when he sowed, . . . some fell upon stony places, where they had not much earth: and forthwith they sprung up, because they had no deepness of earth: . . . but other fell into good ground, and brought forth fruit, some an hundredfold, some sixtyfold, some thirtyfold." And also: "Ye shall know them by their fruits."

This is an epoch of the superlative. The prosperity of our country is at its highest. Our exports and imports have reached the highest figures of a succession of record-breaking years. The crops are so great that our railroads, of greater extent than those of any other country, congested with traffic, are unable to find cars to transport them, and parts of the country are suffering for such necessities as coal, owing to the plethora of others, such as grain. Business undertakings are greater than ever before in the history of the world, and as a consequence we have merchant princes whose wealth beggars the imagination and makes the rich men of antiquity look poor in comparison. Not only have we greater millionaires, but more of them than any other nation, and our total wealth far exceeds that of any other land in this or any other time. Not only have we rich, but our working classes are more fortunate than others; they are all busily

[1] The following article was given as an address at Clark University on Founder's Day, February 1, 1907, and although some of the statements therein made might now be somewhat modified, it has been deemed best to print it verbatim, and without removing the local allusions, since its application is general, rather than particular.

employed, and wages are unusually high and still going up. So fortunate do we consider ourselves that a great political party, with a complacency that almost compels admiration, taking credit to itself for the conditions that have produced these unprecedented results, presents as its watchword, borrowing an elegant phrase from the gambler, the injunction to "Stand pat," on the assumption that conditions are so near perfection that they can not be improved.

Conditions being as I have described, let us imagine an intelligent traveler from Altruria, or from Mars, coming among us, and let us fancy his observations. "Surely," he will say, falling into the superlative, "this is the greatest country in the world. The easy circumstances of your people have undoubtedly left them time for the enjoyment of art, of literature and of science, and have enabled them to cultivate the love of beauty and of truth as no other nation has done. Your rich men have had the leisure to educate themselves to the highest pitch, to patronize the arts so that your architecture, your paintings and your music surpass all others, and have been able to constitute themselves a leading class whose influence by their writings, their scientific discoveries and their civic devotion has made them an aristocracy such as the world has not seen." I fancy I see a slight shade of embarrassment spread over the face of his cicerone, say in New York or Pittsburg, from which he presently rallies, as he points out to the stranger, "To be sure, speaking of architecture, that office building is the tallest structure in the world, overtopping the cathedral of Cologne, and doubling the height of the pyramids; either of those two railway stations is larger than any other; as for music, every family has an automatically played piano, in these two opera houses sing artists paid salaries higher than anywhere else, mostly Europeans to be sure; in this gallery are the most expensive pictures to be had in Europe, no princely family in Europe being able to resist our offers; as to literature, our newspapers are larger, printed faster, in larger type, and containing more news, unimportant it is true, than any others, and as for science, these dynamos furnish more current than any others in the world. As for the power of our rich men, one of them controls more miles of railway than would go around the earth, which he manages all for the benefit of the public, while others freely give their energies to the management of great public institutions which insure what poor we have against the terrors of old age and death."

But enough of imaginary conversation, and let us examine in all seriousness what are the fruits by which America shall be known. Within the last few years we have frequently heard the exultant statement that the United States is now a world-power. What is a world-power? Is it a nation whose armaments are able to wring from all

rivals their richest possessions, their consent to unlimited aggression? What is the power that moves the world to-day? No sooner is the greatest warship of the world, the *Dreadnought,* launched by England, than a still greater one, the *Satsuma,* is launched by Japan. Must we exceed these in order to be a world-power? From the depths of my soul I believe not. What matters it to history how many thousand tons of steel or bales of cotton or bushels of wheat we export to Europe? Is not the question this, how many *ideas* do we export, and is our product commensurate with our material greatness? What care we that Sparta was victorious in the Peloponnesian wars, if she has left to our civilization no reminder of herself, while the ideas produced in Athens will keep her remembered when both her temples and our sky-scrapers shall have crumbled into dust.

Certainly we have some fruits to offer to history. Poetry and philosophy are to-day everywhere somewhat below par, but we have in the one produced Lowell and Whitman, and in the other Emerson, all redolent of the American soil. I do not suppose that I shall be disputed if I express the opinion that we to-day possess no names to be compared with those of Rostand in France, d'Annunzio in Italy, Hauptmann and Sudermann in Germany, Maeterlinck in Belgium, not to speak of Ibsen, but lately gone, from Norway. To be sure, we have novelists, and though Stevenson and Kipling were only sojourners here, we have Howells and James, to say nothing of more ephemeral writers. Still we have in no branch of literature such commanding names as in painting those of Whistler and Sargent, whom we claim as Americans though they spent most of their lives in Europe. The sense of the country for architecture has but recently been aroused, but the enormous progress that has been made in this direction will be admitted by those who remember the exposition buildings of the Centennial Exposition at Philadelphia and compare them with those of the Columbian Exposition at Chicago or the Louisiana Purchase Exposition at St. Louis. We may now find scattered through all parts of the country noble buildings, exemplifying models from Greece, France and Italy, even if we have not been able to originate a national style, unless our tall buildings are to be so considered. In the art of painting we are now able to hold up our heads as a nation, having distinguished exponents of its various branches, most of whom obtained their inspiration in France, if indeed they do not, like the two I have previously named, prefer to live there. Nevertheless the possession of the undisputed preeminence of Sargent among portrait painters and Whistler among etchers may reconcile us to their exile from the land which claims them. In sculpture the same may be said, in a less degree, as in painting, and the possession of St.-Gaudens may reconcile us to his Irish birth and his French name.

But whatever the status of our country in art and literature, it will be said, there is one matter in which we are particularly strong, namely in education. Our common schools are the boast of every patriotic American, many of whom believe that such schools are unknown in other lands; our colleges and universities are in number more than those of any other country, and for our education we pay a greater sum than any other country does or could afford. Education is the one thing of whose value all Americans are convinced, and for which most of them are willing to make sacrifices. Not only do we have the greatest millionaires, as I have remarked, but they give away more money than any others, and education obtains a large share of their benefactions. No other country possesses privately endowed institutions comparable with our great universities, and in none is the generosity of rich men developed to so high a degree, when measured in numbers. It has recently been announced that Mr. Rockefeller has just brought the total of his gifts to the University of Chicago up to the sum of twenty million dollars, while Mr. Carnegie has given the same sum to two institutions of very recent foundation, both bearing his name, and it is to be remembered that in both these cases the sums named constitute but a fraction of the amounts contributed by these great givers to educational purposes. These are but two of the great number of generous contributors to education in our day, and they have been preceded by a long line of others whom we remember with gratitude.

The question now lies near, what are the results of this grand investment in education, in which not only the fathers, but we of to-day, take such an interest? No sensible man to-day asks the question, "Does education pay?" The great question that interests the engineer or the physicist in connection with any apparatus, machine or transformation of energy, is its *efficiency,* that is, the ratio of what comes out to what is put in. If I may be pardoned for introducing a well-worn anecdote, I will remind you of the reply given by the Hebrew capitalist to his wife, interested in family matters, "Isaac, have you noticed how much interest young Mr. Loewenstein is taking in our Rebecca?" "Interest," says Isaac, looking up from his stock report, "Interest—*what per cent.?*" It is precisely this query to which I wish to call your attention to-day—how great is the efficiency of our educational plant, or, in commercial language, what per cent. of dividend does the investment pay? An answer to this may be of interest to future givers, unless indeed they are so permeated by the prodigality of the times that they will give their money in any case, and take their chances of its doing any good. Let us then take a brief survey of the state of learning in the United States. What is the attitude of the public toward learning, and toward the universities and colleges

in particular? What influence do these exert on the ideals of the people? What is the intellectual or spiritual product of these numerous and well-endowed institutions, and what aspects of them are most prominent in the eye of the public? At the very outset of this inquiry it is somewhat depressing to note the divergence of opinion among experts as to what education is, and what it is for. Those who have attended meetings of college presidents or educational conventions can but have been impressed with the diametrically opposite views expressed. To be sure, there are a certain number of pet phrases and theories which we often hear repeated, and one sometimes thinks, in reading the proceedings of "Educators" in session, "Plus ça change, plus c'est la même chose." Education must be for life, we hear. Undoubtedly, but what is life? Does it consist in eating three meals a day, sleeping at night, and the next day the same? We hear of education for citizenship. But is it so hard to be a good citizen that these elaborate and costly institutions are necessary to bring it about? I recently heard a gentleman remark with an air of finality, "Of course ninety per cent. of what a young man gets in college comes from the association with other young men." If this is true, it seems to me that there is something wrong with our institutions, and that the same result could be obtained in a far cheaper manner. This view takes little account of the influence on the young of strong and mature men, veterans in the conflict of life, and of the passing on of the garnered experience of the race. The maintenance of faculties, at least on their present scale, would seem to be quite unnecessary from this point of view. Under the old college régime, the students had far more time and opportunity for association with each other than at present. Have we, therefore, advanced in the wrong direction? Considering the prevalence of such views, it seems to me to be worth while to emphasize the fact that a college or university is, in the first place, a nursery of learning; I mean a place where knowledge is not only *inculcated, but is produced.* It would seem absurd to put forward this view, were it not so often lost sight of. The late Sir Walter Besant, in an article in the *Harvard Graduates' Magazine,* remarked upon the fact that at the commencement exercises that he had attended in this country, he heard much of the public services rendered by the graduates, and of their distinguished contributions to citizenship, but he had heard little of the distinguished scholars that the institution had produced, and that it would appear that that was a matter that was not considered of great importance. At similar occasions at Oxford or Cambridge, he stated, much was made of contributions to the world's thought made during the year by the university's sons, in which achievements the *alma mater* took great pride. I believe the same fact has also been noticed by others who attend academic occasions. In this respect the colleges do not differ

essentially from the public, which is, to speak plainly, little interested in learning, and knows little of those devoted to it. If the future historian, or the traveler from Altruria, wishing to inform himself of the relation of the public to the colleges, should consult the documents, that is the newspapers, could he help concluding that the main business of the institutions of learning, and the one supported by the public, was the cultivation of athletic sports and contests? Are not our largest colleges chiefly known to the newspaper-reading public through the records of their athletic teams? When we hear the "spirit" of certain institutions spoken of, does it mean anything else than a concentration of all the forces of youth on the task of overcoming athletic rivals? It is, to be sure, an inspiring sight to see these forces concentrated on anything of importance with the determination to overcome difficulties, but does not the importance of the athletic success seem magnified out of all proportion, and is it compatible with that sane view of life which should, above all, be the possession of the educated man? Let us consider the amount of interest in athletics on the basis of the sums expended for it in comparison with other departments of activity. In a recent daily paper I find the budget for athletics at the University of Pennsylvania for the past year to amount to $88,863.85. During the same time fifteen colleges and universities in the State of New York, including Columbia and Cornell, spent on books for their libraries $67,587. This is less by $20,000 than the sum spent for the same purpose by the Brooklyn Public Library. We also find that at a single football game there is taken in in gate-receipts the sum of eighty thousand dollars, a sum, I may say, more than sufficient to run this university and college together for a whole year. What a commentary are these figures on American civilization! I do not grudge the expenditure of money on gymnasiums or whatever is necessary to the development of muscle and the maintenance of health, which is the prime necessity for success in any walk of life, but when I find in the above budget the sum of $29,688 for football, I feel a certain sense of scandal. I am aware that certain cities in the days of the decadence of Rome maintained bands of gladiators for the diversion of the public, but I can not feel that we shall do well by imitating them. I have never been able to reconcile myself to the spending by my own *alma mater* of over one hundred thousand dollars for a stadium, while she alone of all the great universities lacks a worthy library building, and can not find the funds to build it.

It will be said in explanation of the public interest in athletics that this is the field of activity most visible, even if the activity is not the greatest. Let us consider what are the fields of activity of a college or university. Founded at first with the avowed object of educating young men for the Christian ministry, our colleges naturally developed

after the model of the English colleges, which, being intended for the education of certain classes in the community, were long dominated by medieval ideas and traditions, and made their main business the teaching of the ancient languages, for, if we include what was then known as "the mathematics" we find it to have been restricted to so much mathematics as was known to the Greeks, as if man's brain had lain dormant since their day. Such was the condition at the beginning of the nineteenth century, and even much later in this country. During this time, however, the modern sciences had arisen, and many of them had obtained a great development, especially mathematics, which, by the invention by Descartes of coordinate geometry, and by Newton and Leibnitz of the Infinitesimal Calculus, had forever emerged from the chrysalis in which the Greeks left it, and had become a thing of marvelous power, fit to display the highest flights of the human intellect. Were these triumphs of mathematics now exhibited to the academic youth? Far from it, they were not even informed that such existed. In fact, we have good reason to doubt whether their existence was known to any one in the country. As far as colleges were concerned, if we consult the diaries of students written a little over one hundred years ago, we find that they were instructed in matters now considered fit for the grammar school. A student at Harvard speaks of running away from recitations and going out to work with a surveyor's compass by way of diversion, but there is no suggestion that he knew anything even of trigonometry, now considered a proper subject for the high school. At the period in question the sciences of physics and chemistry were beginning that marvelous development which has continued to our day. Were the students of seventy years ago made acquainted with the discoveries of Thomas Young and Fresnel in light, of Oersted and Ampère in electricity? We must again return the same negative answer. But come down to the period of forty years ago, when the country was advanced enough to be in daily communication with Europe and to take an interest in intellectual matters, and had by its successful termination of a great civil war put itself in a place of respect among the great nations of the earth. It was then possible, to be sure, to learn a little science in college, but as for the advances that were being daily made in Europe, little enough was known of them. In fact, we must confess that during this whole period we remained in this country in the Rip van Winkle stage with regard to knowledge merely of what was going on in scientific Europe. Did it occur to any of our people that this country had anything to do in connection with this great creative movement of knowledge? That our standing among the nations of the earth was in any way dependent on the production of new knowledge on American soil, and that if we did not expect forever to occupy a position of intellectual mediocrity, it

would be necessary to do more than retail what others had produced. Apparently not to any extent. Scholars we had, to be sure, mainly in the direction of history, and some literary men. We had indeed already produced inventors in the mechanical arts, men of wonderful alertness of mind, who gave a character to the national genius, and did much to help us to the industrial supremacy that we to-day possess. But the pursuit of searching into the laws of nature, with the object of advancing the stock of knowledge of the human race, was then hardly thought of. Who had made the great discoveries which were the chief distinction of the nineteenth century? In some cases persons of private means, sometimes physicians, but more and more professors in the universities of Germany, France, England and Italy, and the smaller countries of Europe. In these countries it has always been assumed that the greatest intellectual activity would be found among professors in the universities, who would be expected, as a matter of course, to produce those fruits in the way of new knowledge that would make the glory of the nation. Thus we find Napoleon, reforming everything in France, surrounding himself with a scientific galaxy of the greatest brilliancy, feeling that this, no less than military success, was for the glory of France. Germany, hardly recovered from the effects of the Napoleonic wars, set about founding new universities or strengthening old ones, and their professors were constantly adding to knowledge in every direction. The spirit of work and of research was the characteristic spirit of the German university. Germany was in this way attaining that intellectual primacy that no other nation may to-day dispute her. In the meantime the universities of England were lagging behind the scientific movement, and ours were still well in the rear of them. It was not until after the successful prosecution of the Franco-Prussian war that the appearance of Germany on the stage as a political world-power began to call our attention to the real source of her power, and finally the wave struck us. Young men then began to go to Germany and to drink in inspiration at the fountain whence it flowed so freely. When my colleague, Professor Story, reached Berlin in 1871 he found few Americans, but on my own arrival fifteen years later the stream had swollen to a goodly number, although it had by no means reached its flood. The advent of the hundreds or thousands of young Americans returning from Germany full of the enthusiasm for production, which it is impossible to avoid catching there, began to have a very decided influence on our academic ideals, and our universities opened their eyes to the fact that there was no reason why we, too, should not contribute to the increase of knowledge.

Let me not be misunderstood, nor accused of claiming too much for the influence of Germany. I know that there are to-day personalities potent in the educational world who alternately pooh-pooh and

dread the influence of Germany. Although I can not sympathize with them, I am far from maintaining that our liberation from bondage to medievalism began when students began to go to Germany. I do not forget Franklin, whose scientific researches made him a great figure in the great world when it was hardly known what an American was, but I must point out distinctly that Franklin was not only the product of no university, but that he was never a professor in one, so that he constitutes no exception to the condition that I have described. I remember also with pride the discoveries of Joseph Henry, the first secretary of the Smithsonian Institution, whose great discoveries in electricity entitle him to be named with Faraday, and had there been here any appreciation of scientific research or had the means of communication with Europe been greater, and especially had not Faraday made most of the same discoveries in England, Henry would have made his name one for all Americans to cherish as a national glory. It is with feelings of peculiar pleasure that I notice, each spring on my visit to Washington, the statue of Henry in front of the Smithsonian, a welcome change from the bronze man on horseback with cocked hat and sword with which the capital swarms, and a quiet proof that even republics are not totally ungrateful, and that they recognize that there are other kinds of glory than military glory.

It would be impossible to pass over in silence the great influence of Louis Agassiz, coming to Cambridge over fifty years ago, who by his wonderful personality not only encouraged many to take up research as a profession, but also kindled the imagination of the public, and led it to see that science was deserving of respect, and not of the suspicion that it had often encountered on religious grounds. Such was the success of Agassiz that we still hear stories of him that would seem to mark him as the first to succeed in opening the purses of the rich for scientific research. Agassiz did more for science than is possible to many; he left a son who not only rose to the highest level among American scientists in the same line as his father, but, more practical in his applications of science, and equally actuated by the desire to advance science itself, was able to exercise a generosity that, until the time of the present millionaire gifts, made him the largest single contributor to Harvard.

It is frequently supposed that the American public is extremely interested in the results of scientific progress, and so it is, in a certain sense. Certainly we can not accuse it of lack of alertness, when it reads more than any other—in the newspapers. It reads with eager interest, and with implicit credulity accounts of the supposed discoveries of science, taking at equal value the productions of notorious charlatans and those of real investigators. It reads with wonder of the discovery of radium, laying particular weight on its costing millions of dollars

an ounce, much as it speaks of Mrs. X's hundred-thousand-dollar tiara, or Raphael's million-dollar Sistine Madonna. With equal interest it reads of the production of energy out of nothing, of communication with the dead, or the discovery of the origin of life. America is, as we know, the favorite resort of new religions, intellectual fads, and isms, ologies and pathies of every sort. As a symptom of the attitude of the public toward science I may mention the fact that the press does not yet consider scientific news to be good business. While every paper of metropolitan standing maintains an expert for literature, for the drama, for music, and many for sport, I know of but three, the New York *Sun*, the *Evening Post*, and the Boston *Transcript*, that retain the services of a regular contributor to acquaint the public with the current achievements of science. I have for years taken one of the great Boston dailies, but I find it almost impossible to find from it who has obtained the Nobel prizes, and I take it as extremely likely that the rest of the public is in the same position, for many had never heard of these prizes until one of them was conferred on the president of the United States. Do not the facts that I have mentioned lead us to the necessary conclusion that on the American field there is no great depth of earth, and point emphatically to the need of both deepening the soil and fertilizing it? When we come to sum up the achievement of this country in science we find ourselves somewhat embarrassed. There are in the dictionary of scientists recently published by Professor Cattell the names of about four thousand men who have been engaged more or less in research, that is, one man in every twenty thousand of the population of the country. Does this look as if the prosecution of science was looked upon as of great national import? Of those who have received the honor here most coveted by scientific men, of election into the National Academy of Sciences, we find ninety, or a little more than one man in each million of the population. Either this body is absurdly limited, or science can hardly be said to be flourishing here. What is the product of these four thousand scientists? I will grant that much of it is of an excellent order, that we have many flourishing scientific societies, and that in many sciences we maintain our own journals which are to be found in every scientific library in the world. But nevertheless it is plain that so far few fundamental discoveries are made here, that we neither discover radium, split up the atom, nor find new gases in the air. The Nobel prizes have not yet crossed the water, nor do they seem particularly likely to in the next few years. In fact we find ourselves in much the same state with regard to science as with art and literature. We have our Sargent and St. Gaudens, our Howells and James, we have also our Michelson and Morley, our Newcomb, Hill and Agassiz, and a good many others of varying degrees of prominence, but not of commanding rank. It seems accordingly

pretty evident that our product is as yet hardly what we might justly expect considering the stress we lay on education and the amount of money we spend.

What is to be done in order to change this state of things, and to relieve the United States from the aspersion of mediocrity in intellectual achievement? Is it not our plain duty to urge in season and out of season the importance of research, and to insist upon it as the main concern of every occupant of a university or college position? I put this not only on the ground of duty to our country in order to maintain her position with self-respect among the other nations, but on account of its preeminent importance as a vitalizing and energizing influence on teaching. If the public does not take a great interest in the doings of the colleges and the professors, is it not because of the fact that the professors do not produce that crop of fruit that may fairly be expected of them? How can the public become enthusiastic over professors whom they consider in the light of pedagogues paid to hear the young men say their lessons, and to repeat over to them what they themselves have read in the books of others? Will not that teacher make a far greater impression on the student if he knows that he is continually occupied in work that is his own individual creation and that is increasing the sum of human knowledge? There is no doubt that the absolutely essential quality in a teacher is enthusiasm, without which it is impossible to exert any inspiration. Who is so likely to possess this quality *sine qua non* as the man who is continually occupied in the engrossing task of wringing her secrets from nature, or drawing new conclusions that his powers of reasoning have enabled him to perceive for the first time? I well remember my first impressions on arriving in Germany. After an experience of five years as student and instructor in Cambridge, where it was considered (among the students, for I will not do the professors the injustice of making them responsible) good manners not to be warmly interested in anything in particular, the entrance into a community where every one was tremendously interested in the piece of work on which he was engaged, and was not ashamed to talk of it, where there were persons enough studying the same subject to make discussion attractive, and where, after a morning in the laboratory, one would adjourn to a restaurant and talk shop all through dinner, this was to me a tonic like the effect of a cold bath. I shall never forget the first time I saw the great Helmholtz. In my anxiety to secure a place in his laboratory, I committed the breach of etiquette of calling on him at his house instead of at the laboratory. Ushered into his study, I found him standing at work at his desk, from which he turned and transfixed me with those piercing eyes. Never in my life have I felt so small and insignificant, knowing myself to be in the presence of the greatest scientist alive. During

the years that I spent in Berlin, I must acknowledge that the help I received directly from Helmholtz was not great, but we all felt such an unbounded admiration and respect for the great man, such a pride in reading his investigations as they appeared, and trying to understand them, that I would not exchange those memories for any amount of assistance in the preparation of a doctor's dissertation. After spending the four happiest years of my life in this atmosphere, when it came time to return home it was with some misgivings that I began to consider the prospects of the life about to begin. On the steamer returning I fell in with a classmate from whom I learned something of a new institution in which great stress was laid on research, a fact that produced an agreeable stimulus in many others than myself, as I have since learned.

The foundation of the Johns Hopkins University in 1876 marked an epoch in education and in science in this country, for into it President Gilman succeeded in gathering such a body of strong and enthusiastic scholars all permeated by the spirit of research and production as had never been got together in this country. What American physicist does not owe something to the life and work of Rowland, what biologist to that of Brooks? From that remarkable circle of inspiring teachers came one who was to furnish the creative ideas for this Clark University, where the idea of research, of the production of *fruit* as the criterion of vitality, was to be emphasized as had never before been the case in this country. The idea of founding a university without a collegiate department was derided in some quarters. "No students to teach! What do your professors do then?" was the question frequently asked. And yet the prospect was unspeakably alluring to many young men. One of my colleagues tells me of a letter that he received from a friend who declared that on reading the first announcement of Clark University he felt like selling all he had and going there. This I believe was the feeling of many others. I was not so fortunate as to be here the first year, but I have had described to me by colleagues the exhilaration of the start in the race, in the company of a band of leaders, mostly young, but already eminent, and every one imbued with the determination to do all that in him lay toward the increase of knowledge and the glory of his country.

Of the history of the university it is not for me to speak. My remarks are not intended to be of local, but of general, application. My main contention is of the indispensability of research, by all teachers, not only in universities, as a means of vivification and fructification. It is hardly necessary to speak of the necessity to the community of research, on account of its practical applications. Of this the public is becoming decidedly sensible. To say nothing of those

great practical utilities, the telegraph and the telephone, the application of steam and electricity in the production and transmission of power, the conquests of biological science in its applications to medicine and the preservation of the public health, are matters of common knowledge. The disappearance of the plagues with which the cities of Europe were so frequently scourged, of the ravages of smallpox so prevalent one hundred and fifty years ago that one person in every three or four was marked with it, and finally the control of yellow fever and malaria, speak volumes in favor of medical research. Who is doing the medical research of the world? In this country the statement is made that out of about one hundred thousand physicians not over five hundred are engaged in research. Fortunately the Germans are at this too, so that every physician has the ambition to study at some period in Germany, and find out all he can of the newest methods of practise and discovery.

The effect of research on the industries of a country is well known. One of the most celebrated applications of chemistry was the creation of the aniline dyes. This discovery, made in England, bore its greatest fruits in Germany, and at the recent celebration in London of the jubilee of the discovery of the aniline colors in honor of Sir William Perkin, one of the speakers said that it was a painful fact that although the English had the discoverer the Germans had the factories. In fact, the Germans not only make the dyes, but the greater part of all the fine chemicals for the world. Every one of these great German factories employs scores of chemists, each with a doctor's degree from a university, not only for the purpose of superintending the manufacture, but for the prosecution of research and the development of new processes and products.

In the commercial race of to-day, England has lost that preeminence that she once had, and is extremely nervous with regard to the competition of the United States and Germany. If we compare the methods of the latter two countries, I believe we shall find a decided difference. In this country success has been achieved by the application of business acumen, in finding out how to save cost by the concentration of huge amounts of business under one management, and by production on a large scale. When it comes to improving the quality of the product, we are not so successful. As a familiar example take the steel manufacture, where we have passed England in the quantity of the steel we manufacture, but if steel is wanted of the finest sort for razors the greatest part of it still comes from England or Germany. The principles of the manufacture of steel are still largely a mystery, and the development of the method that seems to give us the most information on this subject, that of metallography, or the study of metallic alloys under the microscope, has been devel-

oped to a great extent in Germany and France. We see the same tendency to concentration of talent on the business end in the management of our railroads. Can any one doubt that these are now managed with far less energy than twenty years ago? Our railroads are now in the hands of financial magnates, and the attempt to do more business takes precedence of everything else. The great increase in the number of fearful accidents bids fair to open the eyes of our good-natured public to this tendency.

I believe I am justified in the generalization that the American talent has made its success rather in business organization and in invention that did not require great learning than in those lines that require deep thinking and solid study. This is the line characteristic of Germany. For instance, we build great steam engines, but it remains a solemn fact that the finest engines are to-day built in the Swiss town of Winterthur, by the firm of Sulzer Brothers. At the Paris Exposition, in 1900, one did not need to be a great expert to perceive that American engines played but a small part there, and that in originality of design and perfection of construction, those of Switzerland, Germany and Belgium were more worthy of consideration. The notion that we are always ahead in mechanical matters receives several rude shocks on careful examination. Some years ago when the power of Niagara was to be developed on a grand scale, it was determined to install turbines of five thousand horse-power each, larger than had ever been built. For the development of this plant the best talent in the world was obtained, and the dynamos were finally built after the combined suggestions of several American and English engineers. The turbines, on the contrary, were built after designs by a firm in Geneva. And yet this is the country of great rivers and water-powers, and at Holyoke turbines of all sorts have been built and tested for years. The reason that the Swiss were appealed to was that they had made such a study of the theory as well as the practise of turbines that they were prepared to design a turbine of any magnitude. As another example we may take the case of the most important subject now before the engineer in the steam turbine. It is true that there is now on the American market one successful American turbine, but it was brought out years after the Parsons turbine in England, and the de Laval in Sweden, and any treatise on the subject now bristles with the names of German, French and Swiss turbines. As an example of the German *versus* the English method, if we open one of the two or three English books on the steam turbine we shall find a very little theory, some specifications and a large number of examples of turbines built by various makers. Opening the chief German treatise, a huge volume by a professor in the Polytechnic in Zurich, we find at first a treatise on the thermodynamics of steam, then applications to the flow of

steam through nozzles, then the mathematical theory of stresses in rapidly rotating bodies, finally, the application of these principles to the design of turbines, and then a thorough and methodical description of the principal existing types. Hardly, if at all, less important than the steam turbine is the gas engine, which seems for a long time to have been treated almost as a joke by American engineers, while in Germany it has reached an efficiency far exceeding that of the steam engine and has been built in sizes up to four thousand horse-power. The effect of this indifference in this country was to put us far in the rear of even France in the development of the automobile, although this was a country where the wealth necessary for the pursuit of the automobile craze was present in great abundance. In spite of the number of manufactories of automobiles in this country, I am informed that the Fiat Company of Turin is occupied for the next two years with American orders, the result of the success of its machines in international races everywhere.

I will conclude my practical examples with one more contrast. A year ago I visited a great optical plant in this country. There I saw in one room thousands of lenses for spectacles being ground almost without attention. During the day I saw *one* man who seemed to me to know anything about optics. The business was in the hands of the original founder and his sons. I supposed that the latter, having grown up in the enjoyment of wealth, would have been given the best education possible to train them for their business, and possibly sent to Europe to learn methods there. Great was my astonishment to learn that the gentlemen had not even been at college. In the city of Jena is one of the most remarkable and successful industrial plants in the world. The Carl Zeiss works are known to every worker with the microscope, to every physicist, to every photographer in the world, for here are produced those wonderful lenses that make photomicrography and the more wonderful achievements of instantaneous photography possible. The history of the Zeiss works is as interesting as its products. Fifty years ago Zeiss, a small optician, wishing to get help in improving his microscopes, consulted Professor Abbe, the physicist at the University of Jena. The latter, applying his mathematical knowledge, so improved the efficiency of the microscopes that Zeiss invited him to join forces. Becoming interested in the subject, Abbe resigned his professorship and became the scientific partner. Taking up the theory of optical instruments in general, he completely remodeled it, bringing out points never appreciated before, and inventing new lenses that were beyond competition. At the death of Zeiss, his son not having a taste for the business, Abbe was able to become sole proprietor, and at his death two years ago, full of success and lamented by scientists everywhere, he created of the business a Stift, or foundation, for the

benefit of every one employed in the works. This is managed by a board composed of the scientific directors of the different branches of the business, the whole constituting a magnificent monument to German science and cooperation.

If the view that I have taken is correct, the practical question presents itself, what has been done by the colleges and universities in this country to provide for research? I should like to ask all the trustees and governing boards of the institutions of the country the question: Gentlemen, what is your policy—*have you any*—do you believe in research—if so, what provision have you made for it? Do you believe that you have any duty to the nation in this matter? Who, in your expectation, is to do the amount of research necessary to constitute us a world-power in the intellectual sense? Do you realize that the prosecution of research is a very engrossing pursuit, consuming great amounts of time, and not to be carried on in those leavings of moments when the tried teacher has finished his day's task of instruction? That it is also a very expensive process, requiring elaborate laboratories fitted with the ever-changing apparatus quite distinct from the stereotyped stock in trade necessary for the imparting of first principles to the tyro in science? Of the forty million dollars now spent annually in the United States on colleges and universities, what proportion now goes for the provision for research? This it is impossible to tell, but we find that in comparison with the hundred thousand students in our colleges there are only seven thousand graduate students. Of these by far the greater proportion are not to be counted in the research class, but are preparing to be routine teachers of a somewhat superior grade to those who go immediately from undergraduate colleges. These graduate students are largely being taught by professors whose main duties are in undergraduate teaching, and even in our largest and richest institutions the complaint is made that it is impossible for the graduate student to secure any considerable attention from the professor. In many cases expensive laboratories are erected with little or no provision for buying books. I know of but two physical laboratories in this country that have an endowment to be devoted to the fostering of research, the Jefferson Laboratory at Harvard and the Phœnix Laboratories at Columbia.

Fellowships are, to be sure, provided, but not nearly enough. For it is a strange fact that the sons of the rich seldom or never in this country take up learning as a profession, and that most of our serious students have exhausted their means in the four years of college. In a family where there are several children, it is a serious matter to provide a college education for all, to say nothing of the extra three years of graduate work, and the ideas that I have been advocating are so little familiar to the public that many fathers do not understand

what more their sons need when provided with a college training. It is useless to make a comparison with the professional studies of law and medicine—these are frankly bread-studies, while it should be expressly understood that the pursuit of pure science has no rewards of a monetary nature. It must be carried on by those who love it and feel called to it, and are willing to make sacrifices for it, but they need not be expected to go without food and warmth, as we often find such students doing. The national government provides richly for the education of those who are to devote their lives to her defense; is there any less reason for providing for those who are to make her intellectually great? Be assured, intending benefactors, that your money will not be wasted by the devotees of science. Of wasting money there are many ways, but not this. Some time ago I stood on a hill above the campus of a large and rapidly growing university, as it is called. At my feet I counted thirteen buildings completed and in process of erection, those of the latter category representing at a crude guess over half a million of dollars, to say nothing of the vast hole into which a third of a million had been poured to make a Roman holiday, a stadium rivaling Harvard's. Meeting a professor, I fell into conversation with him, and he began to describe to me the needs and resources of the institution, and with pride informed me that the endowment was—about two thirds of the endowment of Clark University and College together. When I thought of our three plain and modest buildings I could not but feel that something was wrong, here or there, and I could not avoid the conclusion that what was spread over such a large surface must be rather thin. Knowing as I did the pitifully small salaries paid the professors in that institution and the feeling cherished by most of them toward their president, a highly successful autocrat of the genus hustler, I did not feel that I had cause to envy the university of X. There are no fellowships there, though there are laboratories, and those valiant souls among the professors who do research do so at the risk of their lives. To secure a position there one is not asked, What have you accomplished? but, What is your denomination? Is this a picture of the typical American university? I sincerely hope not. And yet I fear that the picture is not unfamiliar. Certainly it does not remind us in the least of a picture of a university in Germany or France. A friend of mine, a distinguished professor of mathematics in the University of Paris, has as his regular duties the delivery of two lectures a week for one semester, that is, during four of five months of the year. The rest of his time he has for research. The result is that he is one of the two or three of the world's greatest mathematicians. For the amount of work that I have mentioned he receives what until last year was a full professor's salary at Harvard, the largest, with two exceptions, of any in the United States. And

yet France is a small country, not rich in comparison with us, and with a national debt six times as great as ours. But France has long been a civilized country, and Paris is proud to call herself "la ville Lumière." At the University of Berlin, Professor van't Hoff, the great physical chemist, was called from his native Holland to occupy a chair of research, in which he is totally freed from the obligation to lecture. Can we not consider the possibility of something of this sort in this country?

During the last few years several institutions have been founded for the sole purpose of the promotion of research, most notably the Carnegie Institution of Washington and the Rockefeller Institute of Medical Research in New York. These noble foundations may be expected to produce great results, but they do not relieve the universities from the duty of providing for research themselves, for research can be much more efficiently carried on in connection with teaching, and it is far more easy to obtain the persons who are to do the work in the universities than elsewhere. The scientist who does not have the inspiration of frequent contact with young and active minds of students is likely to become self-absorbed, one-sided and dried up. It is to be noticed that I have made this plea for research largely on the basis of its effect on teaching, and of inspiration of the students and of the community.

What then, my colleagues of university and college, is our duty? First of all, by our lives and precepts to teach our students that the prime object of the educated man is not to make a living. Is not the life more than meat, and the body than raiment? It is ours to hold up the sacred torch, and to radiate upon the community those ideals which it is strangely in danger of forgetting. It is for us to enrich the American soil, and cause it to bring forth imperishable fruit. And by word and deed to remind the young men with whom we come in contact that life is neither pleasure nor pain, but serious business.

THE GRAIN OF TRUTH IN THE BUSHEL OF CHRISTIAN SCIENCE CHAFF

By CHARLES CLARENCE BATCHELDER

"WHERE there is smoke, there must be some fire," is a proverb which may justly be applied to the claims made by Christian Science, for it is hardly fair to a large number of educated men and women to jeer at them as the victims of the absurd delusion that they have been cured of non-existent maladies. Not only can they produce well attested cases of undisputed cures of distinct diseases, without the use of medicines, but similar results occasionally occur at Lourdes and elsewhere, and, in fact, have taken place in unbroken succession throughout the centuries ever since the Temple Cures of Ancient Egypt. Though the facts are too well established to be denied, we may yet question the explanations they give of the cause and method, especially when we find that the Pagan idolatry of the priests of Ammon-Ra produced the same effect as the Pantheistic philosophy which Dr. Quimby and Mrs. Eddy adapted from Hindu sources. For though the charge of Pantheism is violently repudiated, it is even more authoritatively affirmed by the statement "God is All, and All is God."

Now while the philosophy is not convincing to the ordinary reasoning mind, a study of the methods of Christian Science can not fail to command admiration, not only on account of the efficient financial management, but also for the clever use of the most effective methods of mental healing. The fact that these procedures were discovered empirically does not distinguish them from the systems of the recognized medical schools, for the uses of most drugs were found in the same way.

It is also not just to accuse the "healers" of being quacks and charlatans, for, though there may be exceptions, it seems well established that sincerity on the part of the operator is usually essential to produce that conviction in the patient which is absolutely requisite for all cures of this nature in every age and time. In other words, the christian scientists are perfectly right in saying that "faith," conviction, belief, are necessary to produce the desired result, and that doubt in the patient, or among those present, is likely to prevent success. The reasons for this will be apparent later.

The opponents of this system affirm that most of the diseases in question are only imaginary, and do not really exist. Though we

should grant this at the start, it would not alter the situation much, for imaginary diseases are often as "afflictive" to the sufferer, and more annoying and expensive to the family, than actual ailments, and a debt of gratitude is due to any method of removing them.

The next objection is that the patients would have recovered anyway if let alone. Suppose this is also conceded; the position is unchanged, for the chances are that the disorder would not have been left to the curative processes of nature, but would have been dosed with various poisonous patent medicines, with dangerous results. Here christian science is beneficial by preventing interference. But, after all, is this true, especially of chronic cases? We may well ask why, if nature alone was able to cure the case, it remained unbenefited for years, but quickly recovered as soon as mental healing gave its assistance.

The unexplained instances are jauntily disposed of by attributing them to "suggestion," but giving a thing a name is not solving the problem, and, while there are reams in the text-books upon the effects of suggestion, few seem to attempt to say exactly what it is or how it acts.

The whole subject of mental therapeutics is so discredited that the medical profession hesitates to treat it, but, really, few fields will more quickly repay the application of modern scientific methods. Light even appears in the dark maze as soon as we begin to classify the more reliable cures, as distinguished from those not sufficiently verified. The great majority are disorders of the nervous system, including under this head certain functional affections, and many more are dependent, directly or indirectly, upon morbid conditions of the circulatory system.

Mental healing has not yet demonstrated its power to cure diseases caused by microorganisms, like malaria, pneumonia, diphtheria, yellow fever and many others, and its adherents admit that it is not effective in surgical cases or those where there has been an actual destruction of the tissues. Christian scientists are often taunted by their friends with being unable to cure common colds (caused by bacteria), and with going to the dentist, and with reason, for both these are beyond their powers. They would lose nothing, and would allay much hostility, if they would frankly admit that, for the present at least, these complaints are beyond their scope, and would confine themselves to more successful fields, instead of claiming that they are able to "demonstrate" over cancer and smallpox.

The community has a right to protect itself, and should take measures to prevent individuals from endangering themselves and their neighbors by refusing medical aid in even the minor contagious and infectious maladies. It is somewhat surprising that the able

leaders of this movement have not made some attempt toward a solution of this difficulty, which is the cause of much of the current enmity. They must certainly realize their own limitations, and should be clever enough to devise some edict on the subject which would attain its object without impairing the faith of their adherents.

The subject of nervous disorders is so complex that it seems at first hopeless, but the approach by the way of maladies of the circulation is more encouraging, though less traveled. One clue to this labyrinth was discovered many years ago while some young persons were under treatment for excessive blushing, which took place to such an extent, whenever they were addressed suddenly, as to be a source of great annoyance.

The first suggestion was to think of something terrifying whenever the feeling of reddening took place, upon the theory that terror tended to produce pallor, and would thus neutralize the blushing. This was occasionally successful, but it was always difficult to hold a vivid idea of fright, and the repetition of the idea robbed it of its effect, while the stock of new thoughts of this nature soon became exhausted.

The next step was for the patient to hold firmly the idea that he was not going to blush, and to refuse to believe that he was, even if he felt the warmth in his ears. He must *know* that he could not blush, and that he was not blushing. This worked now and then, but the patient naturally found some difficulty in believing that he was not blushing, when he could feel that he was, so the process was only useful when it was started well in advance of the tendency to redden. Here we have an exact parallel to the Christian Science doctrine, "Deny error! Evil and disease are non-existent!" No matter what the facts are, ignore them, and hold firm to the *ideal* that you desire. We see here a universal principle, the ideal must be made real, in spite of all obstacles. Now we may laugh at this system all we wish, but we shall in the end be obliged to admit that in every age it has achieved the wished-for results in minds of a certain class. It has a real scientific basis, however, as will be made clear later, but has the fatal defect of being inapplicable in many cases, because of its conflict with common sense.

Decided progress was made when the patient found that the flush would vanish if he said to himself firmly, "I know that I can stop blushing if I want to, and I will." This was only attained as the result of patient effort, assisted by strong auto-suggestion, by faith in the operator caused by the previous successes, and, as was learned in later cases, by incipient voluntary control of the arteries of the face. Great self-confidence on the part of the operator was required, together with considerable talk about "will power," "self mastery," etc.

Those who have read the books on mental healing will see that the

three processes here mentioned—counterbalancing one emotion with another, denying the existence of the objectionable phenomena, and assertion of self-mastery—combined with belief in the process—and in the operator, form a large part, if not all, of the various systems, when stripped of unessential details.

The subject proving interesting, more scientific methods were adopted. The best results were attained in subsequent cases, where the subjects were intelligent, by dropping all indirect methods and by simply explaining to the patient that the walls of the capillaries and small arteries of the face, like all others in the body, are composed of circular muscular fibers under the control of special nerves. If the latter are stimulated in a certain manner, they allow the muscle rings to expand, thus increasing the size of the tubes, and allowing more blood to reach the skin, which causes blushing. If these nerves are stimulated in another manner, the rings contract, the bore of the tubes diminishes, the blood supply is cut off, like the stream of water when a garden hose is stepped on, and pallor results. Under normal conditions, these nerves are stimulated in both ways automatically, but by persistent effort it is quite possible to acquire the art of stimulating them at will either way, just as some people learn how to cry at will, instead of being dependent upon saddening emotions.

Here we have a truth of great importance, which is the foundation of all that follows. The action of the organs of the body is quite clearly influenced by mental states, such as fright, embarrassment, sadness, etc. We can cause at will the same effect, which usually only takes place involuntarily, by producing a mental image of an emotional state, by denying the existence of an existing state, or by acquiring the power to give the same kind of stimulus that mental emotions produce without the actual presence of any emotion. The feeling called "faith" is one of the strongest emotional stimuli, and is so powerful that it produces its result, even masking other emotions. The belief firmly held that we are about to cry, even where there is no cause of sadness present, will very often elicit real tears.

If this principle is firmly grasped, logical progress is rapid. An inflammation of any kind is evidently merely an excess of blood supply to the affected part—a sort of local blushing. The converse is an under supply, which starves the cells by failing to provide sufficient nutriment to them, and also poisons them by not removing rapidly enough the lactic, uric, and carbonic acids which are the waste products of all cell activities; for, as we know, the blood resembles those brooks which flow through oriental villages, serving both as sewers and as water supplies for all domestic purposes. The blood, in addition, transports the food assimilated by the digestive organs, the oxygen absorbed by the lungs, and the fluids secreted by the various glands.

Clearly, if we can control the blood supply to the various organs, many problems of disease are mastered. There is, however, one slight difficulty; though we can in a measure control some local nerves, most of those regulating the circulation are beyond the province of our wills. It seems as if nature were willing to trust us with minor matters like motion, but preferred to attend herself to subjects of real importance like digestion and circulation, while we are forced to conceal our humiliation by saying in a learned manner that "assimilation and circulation are functions of the sympathetic nervous system, not of the higher centers!"

Are we balked? Well, not necessarily! If the highway is blocked, there are yet the by-paths of attention and incomplete motion. While most of us are unable to control our blood supplies by a direct effort of the will, all of us can do it indirectly to some extent. Have we been reasoning in a circle, and are we still upon mere hypothetical ground with the mental healers? Not a bit of it! We here emerge from the perplexities of theory and stand upon the firm foundation of instrumental measurements, owing to the labors of a number of investigators, prominent among whom are Dr. Wm. G. Anderson, director of the Yale Gymnasium, and Dr. Angelo Mosso, of Turin.

Dr. Anderson places a student upon a low, legless table, about the size of the body, so delicately balanced that a breath will make it move, and outlines his figure so that he can resume his position after leaving the "muscle bed" temporarily. Now every exertion, mental or physical, means that more blood must be supplied to the active part, thus increasing its weight, while as the amount of blood in the body is limited, the excess must be taken from some other organ, thus decreasing the weight of the latter. If the man on the bed rises and dances a jig, when he resumes his place upon the balanced bed, his feet will sink, and his head ascend correspondingly.

Now this is nothing startling, as we all know that a member if exercised, will grow at the expense of idle organs, which tend to atrophy from disuse. Now it seems as if we had wandered from the subject of the mind, but we shall soon see that even here the mind is an indispensable factor. Curiously enough, if the man does not leave the bed at all, but merely *thinks* of dancing a jig, simply mentally going through the incomplete motions, but taking care not to move a muscle, the delicately balanced bed will sink at the foot almost as much as if the exercise had actually been performed.

Now it is clear why the Christian Scientists say to a person troubled with cold feet "Hold the thought that your feet are warm! Deny the 'claim' that they are cold"! It is reasonable to suppose that the feet of one of the mental believers would sink upon the muscle bed just as rapidly as those of the mental jig dancer, though we can not give

the statistics, as unfortunately it seems extremely difficult to persuade the disciples of Mrs. Eddy to lend themselves to investigations of this sort.

We can even go a step further with the utmost confidence, and say that simple concentration of the attention upon a given part will increase the blood supply. This is capable of experimental verification, for very many people can cause the backs of their hands to redden perceptibly by fixing the attention upon one spot for some time, without the thought of desiring a flush, though that idea usually hastens the process.

This furnishes us a key to some obstinate chronic diseases, where there is no destruction of the tissue, but where an unwholesome condition has resulted from an oversupply of blood caused by undue fixation of the attention upon the part, a permanent blush, so to speak. As the health of the body depends upon the preservation of a normal blood supply, modified by the demands made by the activities of the different organs, we see that an organ constantly oversupplied becomes diseased, like a man who habitually overeats, while this oversupply must be taken from the share of some other portion, which consequently starves. If this is so, it is evident that a cure will follow when the unwholesome attention is discontinued. This shows why the Christian Scientists say "Deny error. If your 'mortal mind' has a claim that an organ is diseased, stop thinking about it. Hold the thought that it is completely well, that you are perfect." This whole line of thought is well conceived, and tends toward mental poise and bodily well-being, for those who are able to believe the tenets.

Having secured some clear ideas about the physiological reasons for some of the Christian Science methods, we are ready for the more difficult aspect of the subject, that of nervous disorders. Every practising physician is confronted with a class of cases in which there does not seem to be an adequate cause for the symptoms, and which are roughly classified under the head of hysterical affections. They include paralysis of various organs, stiffness of the limbs, pain and swelling in the joints, pain in the head and spine, perversions of sensation, over-irritability of various functions, and a host of Protean symptoms. The sufferers suffer actual pain, and often very serious inconvenience, but the most careful medical treatment seems unsuccessful. The limits of this article will not permit a discussion of this subject, but it suffices to say that to all intents and purposes the maladies are real, even though they exist only in the imagination. They seem akin to "fixed ideas," and "pain habits," as well as to that phenomenon called the "balky will" frequently met with in childhood, where a child refuses to obey, and then holds the idea so firmly that it is physically and mentally impossible for him to yield. We have all seen it in balky

horses which refuse to move until their attention is distracted by a lump of sugar, blowing into the ear, or putting a pinching instrument upon the lip, which succeed where a severe beating only increases the obstinate immobility. Many cases of such fixed ideas are on record, which have been cured by fright. One old doctor was in the habit of curing bedridden patients by letting mice loose on their beds, until they ran shrieking from the room, forgetting all about their ailments.

In a recent case, the husband was sent for the physician, leaving the patient alone in the house. The telephone rang so continuously that she rose and answered it, and was so absorbed in scolding him for not returning in time to receive the call that she forgot that she was out of bed for the first time in years. One man who had a most severe case of asthma, which had caused him the most serious discomfort, was completely cured by the fright of the Kingston earthquake, and has had no relapse, though forced to live under conditions of considerable hardship. This is vouched for by the writer out of his own experience.

Now, while cases of this nature are very refractory to drugs and other medical treatment, they yield with surprising readiness to mental therapeutics. The attention of the patient is distracted, a desire for cure is firmly implanted, interest is excited, and all the conditions are made favorable. The process is not dissimilar from that of stimulating the motion of balky horses with lumps of sugar. The fact that there is no real disease evidently accounts for the failure of the skilled physician.

The successes of Christian Science are largely in these cases, which are principally found among women of the middle and upper classes, who live luxurious, self-indulgent lives, are over-fed, under-exercised, have no occupations or absorbing interests in life, and concentrate their attention upon themselves and their ailments. We are not surprised to find that converts belong very largely to this class, or to learn that many relatives bless any belief that will turn a nervous, sickly, complaining invalid into a cheerful, though perhaps a bit too superior and self-complacent member of society.

A very large percentage of all the cures of all systems of medical treatment without the use of drugs may safely be classed under some of the heads which we have already discussed. It is not unreasonable to group with mental healing many methods more generally accepted by the community, such as "high dilutionist" homeopathy, osteopathy, massage, electricity, water and bath cures, and even allopathy, which, as every physician knows, habitually employs "bread pills" and other similar methods of influencing the minds of the patients.

Making all allowances, however, there are a number of cases of genuine cures, as the result of mental treatment, of serious diseases, which have defied all regular medical processes. The discouragingly

dry way of classification will be again most helpful here, as it shows us that these cases are mostly of "functional disorders"—when the organs of the body fail to perform their proper work. It is clearly impossible that any cell in the body should work at high pressure all the time, for adequate rest is essential to all living matter; further, it would be wasteful for secretions to be made when they were not needed, and nature abhors waste, while useless secretions would tend to produce sickness. It is one of the duties of the sympathetic nervous system to stimulate the activities of each organ at the proper time, and also to stop the process when no longer needed. It consists of a double chain of masses of nervous tissue, called ganglia, lying inside and on both sides of the spinal column, connected with each other by nerves, and also with great networks of nerves called plexuses, which govern the heart, blood vessels, intestines, liver, lungs and other organs. The spinal ganglia receive branches from the spinal nerves, which bring them into relation with the cerebellum and brain. The mechanism works reflexly, without the interference of the will. If, for instance, we ascend a mountain where the air is rarer, the lungs work more rapidly, as the result of more frequent stimuli from the sympathetic, thus taking enough more air to counterbalance the deficiency of oxygen. The presence of waste in the circulation stimulates the kidneys, a high temperature excites the perspiration, and the proper conditions cause the other organs to act. The exciting cause in the organ, whatever it may happen to be, sends an impulse up to the reflex centers, which in turn send an order down to the organs to get to work until commanded to stop. If by any means we can send a similar impulse up to the reflex centers without the presence of the usual exciting cause—a false alarm, so to speak—we shall get the regular result. It is also probable that the reflex centers can be made to give the regular orders to start work, not in the customary way by a message sent up to it from the organ, but by direct command of the lower parts of the brain, though not immediately by the cerebrum, or thinking portion. The functions of the sympathetic system are modified by the two pneumogastric nerves which start in the head and extend to the digestive organs, lungs, heart, liver, stomach and other organs.

It will, perhaps, be clearer to select one organ as a type of functional disorder, and follow the process closely, bearing in mind that these remarks do not apply at all to cases where there has been an alteration in structure, as these are not susceptible to mental healing. We will choose the stomach, the most abused organ, as it is defenseless against the acts of the will in putting into it all kinds of injurious substances. It takes its revenge, however, for ill-treatment, not only by causing pain in its own vicinity, but by instigating pain in the chest, dizziness, sleeplessness, headache, black specks and other dis-

turbances of sight, palpitation of the heart, cold hands and feet, general indisposition—called "that tired feeling"—irritability, melancholia, bilious attacks, and other affections. It is interesting to note that if a disordered stomach can be relieved by mental therapeutics, all these symptoms can also be cured by the same means, to the great glory of the healer.

Now the stomach is a patient thing, more patient even than a donkey, but if ill treated too long, it will rebel—go on strike—and decline to handle "non-union materials" in the shape of improper or badly cooked food. Overeating, bolting, insufficient chewing, irregular meals, over-indulgence in alcohol, tea, coffee and tobacco, are, also, apt to produce that prevalent American disease—dyspepsia. The usual factor is a change in the gastric juices, which may be deficient in quantity, or may contain too much or too little acid or pepsin. Sometimes, however, the natural movements of the stomach become irregular, and the food is either hurried too soon into the intestines in a half dissolved condition, or, more frequently, retained too long in an undigested state to ferment and cause pain, gas and vomiting.

Now improper conditions of both the gastric juices and the movements result from a failure of the stimuli of the nervous system. The messages sent from the mucous membrane lining the stomach to the reflex centers stating that food is awaiting digestion may not reach the proper destination, owing to unnatural conditions of the nerves or ganglia; the reflex centers may not give the proper orders; the return nerves may fail to transmit; or the cells of the lining membrane may decline to obey orders. To use the simile of an electric bell—the push button may be broken; the wires disconnected or cut; the batteries may be used up; or the tongue of the bell may be loose.

Such failures of the nervous system are usually the result of overwork of some kind; it is simply tired out, and insists upon rest. The fatigue may be direct, from overeating or improper food, or it may come from general exhaustion from dissipation, worry or mental or physical overexertion. In many cases, simple rest, with freedom from worry and overwork, is sufficient to work a cure. Drugs often actually delay recovery, and we do not really know just why bismuth, rhubarb, nux vomica, gentian, or the newer proprietary and synthetic remedies should assist nature, though we have concluded for empiric reasons that they do. Mental healing certainly gives the nervous system a chance to recuperate undisturbed, and hence is often better than any other treatment. Often, nevertheless, rest is not enough. The rested nerves are still obstinate, and refuse to send the needed orders, resembling balky horses which must be coaxed with sugar. In these instances, also, mental methods will often start the proper reactions when everything else has failed.

Some experiments performed on dogs whose stomachs were kept open for observation will, perhaps, make the situation more clear. If a dog was allowed to eat meat in the usual way, its presence in the stomach caused the reflex centers to send orders to the gastric cells to commence secretion. The mere irritation caused by the presence of objects in the stomach was not enough, for the introduction of indigestible substances, or rubbing the lining with sand, or a glass rod, produced no gastric juice. Meat introduced directly from the outside, not through the mouth, still stimulated the juices. Thus it seemed to be purely a reflex performance—the ganglia seemed to say "you press the right button, we do the rest," the mind seemed to be unnecessary. Nevertheless, if the dog was allowed to swallow the meat, which was removed through a slit in the throat, and not permitted to enter the stomach, gastric juice was as cheerfully secreted as usual. This was puzzling enough, but worse was in store, for if the dog smelled and saw the meat, without even biting it, gastric juice was formed in larger amounts than if the meat were put into the stomach without the knowledge of the dog. Plainly, reflex action here played no part, and mental conditions of anticipation, pure *emotion* in fact, occupied the whole stage.

In other words, the stomach may be controlled in two ways, either mechanically by contact with food, or mentally by the production of emotions. If one fails, the other is still available. If food does not produce gastric juice, the proper mental states may be made to supply the deficiency. The problem of mental healing is here made absolutely clear; we can no longer deny that it is possible. The only difficulty is the method of production of the proper mental and emotional states. This is the most important and fascinating aspect of the subject, but space forbids its discussion in this place, as it leads into the realm of hypnotism, subliminal consciousness, suggestion and double personality. The experimenters were unfortunately unable to obtain data about the mental conditions of the dog, and thus we can not state what the results would have been upon its stomach of the memory of past feasts, the hope of future ones, or the belief or dream that there was meat in the stomach. We must wait for a satisfactory knowledge of the whole subject until some person shall appear with an opening into his stomach, like Alexis St. Martin, who, to our intense regret, died too soon to demonstrate the facts of christian science.

Not only is the stomach largely influenced by mental states, but we all know that joy, sorrow, anger and other emotions cause that extremely rapid and violent action of the heart that we call palpitation, while fright stops its action, through the pneumogastric, so that fainting occurs, or even death. Rage and other mental conditions sometimes intensify the action of the liver enough to bring about

jaundice, while many public speakers and soldiers know that fright causes perspiration and stimulates the action of the kidneys. In short, there are instances too numerous to mention of the effect of mental states upon the organs of the body, and the facts may be considered as established.

While the proper mental states tend to stimulate the nervous system, and restore normal conditions, anger, worry, fear and doubt tend to lower the tone of the nervous system and check the functions. It has been conclusively established by observation that favorable results from mental methods are practically impossible unless the patient has confidence; he must *believe* that the desired effects will be produced; in short, he must have *faith*. There are countless instances outside the realms of mental healing to prove this, notably the cases where people have taken astringent pills by mistake, and have yet been purged because they expected to be. In one particularly amusing incident, a doctor gave a man a prescription for an affection of the stomach, saying, "Here, take this!" Later, when the patient returned to render thanks for his recovery, the physician had forgotten the remedy he had used, and asked to see the prescription. He was naturally somewhat surprised to hear that the man had swallowed the paper, and had taken no other medicine. In this category, also, belong the cures from amulets, charms and incantations. Every doctor of experience will admit that confidence on the part of the patient, and expectation of recovery are half the cure.

If now, these ideas are well founded, and mental states will cure functional disorders as well as those of the circulation and nervous system, why not abandon medical treatment altogether, and adopt some form of mental therapeutics—accept the beliefs of the christian scientists? Well, in the first place, mental healing will not work on all people; some can not accept the requisite theories; others do not seem able to produce the essential mental states; and others are so violently opposed to the whole system that exactly contrary results appear. Next, the methods are unreliable; they will work at one time, and later fail on the same person under apparently identical conditions, while the healers generally are not skilled enough to bring about satisfactory effects, for the whole system is in the hands of unscientific persons, whose methods outrage common sense and arouse hostility toward the many excellent features of their philosophy.

Most important of all, mental healing is powerless in very many kinds of illness, including most of those which are fatal or even dangerous. If mental healing is resorted to, the disease may become established before its nature is recognized, and the patient may die, when if he had been treated by regular practitioners he would have recovered. In all contagious and infectious maladies the patient be-

comes a menace to the community, since quarantine and disinfection are prohibited by the mental healers, as tending to confirm the patient in the "claim" that he is ill.

While the exact method of the action of drugs is uncertain, and many are probably inert, if not harmful, we are positive that certain ones, like quinine, mercury, opium, digitalis and others produce certain definite conditions which can be relied upon to assist the patient. Some of them kill the germs, just as boiling destroys the microbes of typhoid fever in water; others, like quinine, render the human body an unfavorable culture medium and discourage the "bugs"; others directly stimulate the action of the organs.

Even the more advanced mental healers admit that, at present at least, they are unable to treat with success surgical cases, which should at once be examined by a regular surgeon. The former err, however, in refusing to use antiseptics when prescribed, as they are rarely able to practise aseptic methods.

In addition to drugs, modern medicine is making great use of serums of various kinds, and antitoxin has rendered diphtheria, once a household terror, a relatively non-fatal malady. Further advances are being made daily along these lines, and great discoveries may be expected from the investigations of Metchnikoff into immunity and ferments.

Mental healing also errs in not employing to the full diet, fresh air, exercise and the other hygienic systems, which are rapidly growing to be our chief reliance in the control of illness.

It is a source of wonder to those who are following the subject that the usually acute leaders of mental healing do not profit by the experience of the Fathers at Lourdes. The latter have every patient examined by physicians, trained in the regular schools, before mental healing is attempted. This gives an opportunity to eliminate the dangerous or contagious maladies, while at the same time furnishing proof of cure and establishing the nature of the disease. It would seem possible to arrange this so as not to undermine the faith of the sufferer, as the process at Lourdes seems to meet with the approval of the Fathers.

The great weakness of the schools of mental therapeutics seems to be faulty diagnosis. In fact, there is apparently no attempt at diagnosis, and all patients are treated in the same general way. Thus time and strength are wasted on cases which are, from their very nature, hopeless from the start, and in which mental methods are absolutely criminal, on account of the danger and suffering of the patient and the probability of propagating disease in the community. It is not too much to say that no case should be treated mentally until it has been examined by a graduate of a reputable medical school, and pro-

nounced not dangerous to the neighbors or likely to result fatally to the patient. It is for this reason that there is justification for the movement to restrict the practise of mental medicine, which would otherwise be an unwarrantable interference with individual liberty. It would seem possible to compromise the various warring interests, by requiring all mental healers to pass an examination, before receiving a license, in anatomy, physiology and diagnosis.

The whole subject is one which calls for tolerance and impartiality. Both sides claim too much. We have reason to believe that a very large proportion of all maladies can be materially assisted by mental healing, either alone or in connection with medical treatment. Even surgical and infectious cases may be benefited by improving the general tone and keeping up the spirits of the patient. In many ailments, however, this system is absolutely useless, while in another class regular treatment is unavailing, and mental methods are likely to succeed. It is a hopeful sign that a few physicians are devoting themselves to mental therapeutics, and that others send their nervous patients to the christian scientists. There is a field for both, and the two schools ought to work in harmony. One great bar to this is the prejudice, not only of the medical profession, but of the more intelligent portion of the community, against the new system, well founded, without doubt, on manifold errors, abuses and unreasonable claims. On the other hand, while there is much in the philosophy of christian science which is satisfactory to many minds, especially the portions resembling the Hindu beliefs as developed by Kant, the rest is illogical and irrational, and can not be accepted by thinking intellects.

The christian scientists have undoubtedly made many useful advances, mostly by pure empiricism, but these results are not essentially bound up with the christian science beliefs, and can be applied fully as well by any of the other christian churches. These methods can be studied, and are at the service of any one who will take the trouble to master them. It is a fact that they will work just as well with a pagan religion as with a christian one, as a doctor can cure a Chinaman of malaria as readily as an American. On the other hand, while the processes of mental healing can be applied by any one, and are being used daily unconsciously by many medical men, yet the essential elements are more easily furnished by the church, and it is most encouraging that one of the episcopal churches in Boston is adopting mental healing with gratifying success. The emotional nature of man, which controls mental healing, is intimately connected with his higher aspirations, and belongs rather to the domain of religion than to that of medicine.

A VISIT TO THE HANGCHOW BORE

By Dr. CHARLES KEYSER EDMUNDS
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II

The Great Sea-wall

JUST when and how and at what cost the present substantial sea-wall was built are now matters for more or less conjecture, the chroniclers of the province neglecting such information as irrelevant in comparison with fanciful legends to be retold in connection with so great a work.[3] One of the most interesting of these stories refers to what was perhaps the first attempt at anything like an adequate sea-wall. It is to the effect that in the region of Emperor Huang Wu (25 A.D.) an official, Hua Hsin, proposing to build a sea-wall opposite the present site of Hangchow, issued a proclamation offering 1,000 "cash" (about fifty cents gold) for every man-load of earth that the people should bring to the river bank. On the appointed day great crowds of men, women and children came to carry earth. At a signal every one took up his load and carried it to the spot indicated by Hua Hsin's lieutenants. At this juncture Hua Hsin himself appeared and, feigning surprise when told of the large wage to be paid per man-load, he ordered the people away, saying it was utter nonsense to talk of such high pay. Indignantly the people threw down their loads and walked away, thus unwittingly dropping the earth just where the wily official wanted it. "Thus in one day Hua Hsin, by his trickery, built a sea-wall of great height, and one that withstood the briny waters for many years."

In spite of this assertion of the native chronicler, however, a dyke built in this fashion was sure to prove too flimsy to withstand the impacts of such tides as sweep the bay, and we are not surprised to find frequent references to daily sacrifices and prayers to the Water Dragon for protection against the powerful waters. It was not until the period of the Five Rulers that these prayers were answered by the appearance of a man of works as well as of faith, the "great Prince Ch'ien," Hangchow's most famous man. Many places of interest about the city still bear his name in recognition of his great services to the people, which included besides the less tangible, though none the less real, benefits of a wise and capable government, the more "substantial" benefits arising from the efficient fortification of the

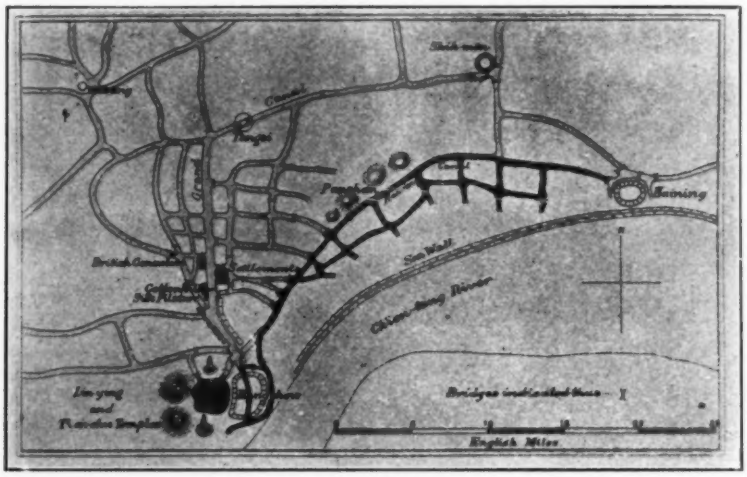
[3] For a fuller account of these legends see F. D. Cland's "Hangchow," Shanghai, 1906.

ALONG A SIDE CANAL.

ON A BY-WAY CANAL.
(Taken in the rain.)

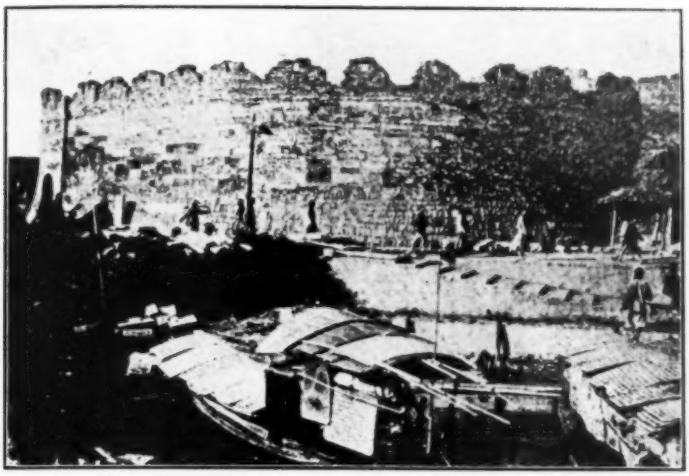
capital city, the preservation of the West Lake as a water-supply, the building of public roads, institutions of learning and canals, and, in view of the present considerations the most worthy of all, the long sea-wall which stands to-day as the greatest monument to his skill and efficiency in caring for the public weal. Its erection was begun probably about 911 or 915 A.D. It extends from Hangchow to Chuansha near the mouth of the Whang-pu (the river on which Shanghai is situated), a distance of one hundred and eighty miles. It is a stupendous piece of work and deserves an equal share of fame with the Grand Canal and the Great Wall of China, for its engineering difficulties were certainly infinitely greater.

Unfortunately there appears to be no record of how these difficulties were really overcome, although as usual the native historian



WATER-WAYS NEAR HANGCHOW. THE HIGH-LEVEL CANALS SHOWN DARK.
(From Decennial Reports C. I. M. C., 1892-1901, Shanghai, 1906.)

has felt impelled to leave a rather poetic narrative concerning an achievement so vital to the inhabitants of so large a region. Considerably abbreviated, it is to the effect that by petitioning Heaven to withhold the tides for two months and inditing a poem to the Water Dragon, beseeching the loan of the water's control for a brief time, the energetic and dauntless Prince Ch'ien was enabled to prevent the thousand sprites and the one hundred demons from bringing in the tides by having five hundred skilled archers shoot three thousand specially prepared arrows directly into the oncoming billows. Each man took up six arrows, one for each billow, and when they had shot five arrows straight into as many lofty waves, the waters suddenly turned and fled! Whereupon the Prince quickly drove great piles along the river bank, among which strong creels of bamboo were woven,



CITY WALL AND GATEWAY AT HAINUNG.

the whole being filled with earth and large stones. "Thus he connected the two ends of his wall and shut out the destructive waters," and thus, we may add, does the chronicler avoid telling us the essential details of the very part of the construction, which in its successful accomplishment constitutes the chief wonder.

But it was not enough simply to build the wall; it must be kept in repair, and, curiously enough, the native chroniclers have accounted most minutely for the cost of the up-keep, which is said to be on the

HAINUNG PAGODA AND PAVILION.

THE BORE WALL AT HAINING, SHOWING THE SEA FOOT.

average 250,000 taels per annum, which has led many people of this region to call this sea-wall "China's Second Great Sorrow," giving place to only the Yellow River as her "First Great Sorrow."

For purposes of management and repair the wall is divided into three major divisions with a superintendent over each. These divisions are again divided into many sections about a mile long, and for each mile there are at ordinary times four to six watchmen who patrol their section much as railroads are patrolled.

The first cost of construction must have been enormous, and the mere existence of the wall suffices to show that it must have been of vital importance and that the land it reclaimed and now protects must have been of immense value to justify such an expenditure.

As it exists to-day its total length is one hundred and eighty miles, and for one third of this distance it is faced, as at Haining, with heavy blocks of granite and varies from twenty-five to thirty feet in height above low water. Each successively higher layer of granite slabs recedes about five inches, thus forming steps, a very welcome arrangement when, after descending to get camera views of various parts of the wall just before a bore was due, we had hastily to retreat before the oncoming flood.

The main difficulty in maintaining an efficient sea-wall would seem to be to have an outer footing adequate to break the first violence of the incoming bore and to prevent the undermining of the foundations of the main bunding—in fact it would seem essential that the tides

should be entirely kept from entering behind the wall. At Haining the Chinese engineers have succeeded in accomplishing this very satisfactorily in a twofold fashion—viz., by a sea-foot proper and by frequent projecting "buffers," a combination which, besides giving a substantial sea-barrier, also affords excellent and frequent refuges for the junks whose masters must needs brave the dangers and difficulties of navigation in a river so fiercely tide-swept as this is.

At the level of the sixteenth ledge from the top, in this step-like face of the wall just referred to, *i. e.*, about twenty feet below the top of the wall, there extends outward a heavy granite platform several layers deep and about fifteen feet wide. At the outer edge of this several rows of piles are set close together and deeply driven into the river-bed. Here there is a drop of four or five feet followed by another shelving granite platform, somewhat wider than the first and similarly edged with several rows of much heavier and more numerous piles. Here there is a further drop of six or eight feet to a sandy beach which for a yard or two is rock strewn and studded with piles, a ragged fringe of which about ten feet farther out marks the outer edge of this remarkable barrier.

At intervals of half a mile, at least in the immediate vicinity of Haining, huge projecting buffers in semi-elliptical form have been built of brush and piles. The ends of the brush, which has been stacked and interwoven in horizontal layers, are presented on all sides and down through the mass several concentric rings of stout piles have been

FROM THE TOP OF THE SEA WALL DURING THE AFTER-RUSH. COMPARE WITH THE LAST PICTURE AND NOTE CHANGE IN WATER LEVEL.

VIEW FROM THE TOP OF THE SEA WALL, SHOWING THE SUCCESSIVE LEDGES OF THE SEA-FOOTING AND A BUFFER IN THE DISTANCE.

driven. These buffers are slightly higher than the sea-wall itself and also extend out beyond the last row of piles which forms the edge of the wall's sea-foot. Topped with earth which affords a rooting-place for bushes and small trees, they constitute a notable feature of this very creditable piece of Chinese engineering. Some idea of the destructive force of the bore may be had by inspecting the first buffer east of the pagoda. It is about one third demolished, so that instead of a well-rounded form it now consists of four or five distinct terraces, which are probably constantly settling down and pushing the lower terraces into positions affording less resistance to the tide. On the other hand, the buffer just west of the pagoda is in splendid repair and behind it high up on the topmost granite platform several junks were enjoying a safe shelter.

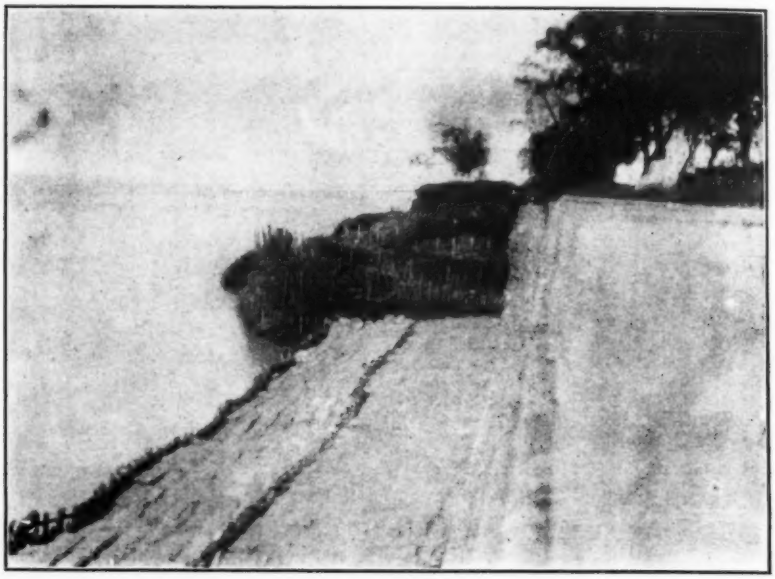
The stones on the top of the wall are from twelve to sixteen inches wide, sixteen to eighteen inches thick, and from three and a half to four feet long, and most of the blocks used both in the wall and in the platforms of the footing seem equally large. Along the top of the

wall adjacent stones are fastened together by heavy iron mortises in the shape of a double wedge (⧗) four or five inches broad, two linking each pair of stones. Whether the lower layers of blocks are mortised in the same way we were unable to determine, though a friend has reported that he has observed these links also in the slabs forming the footing-platform, but we saw none in the part we examined.

On the top of the bunding from Hangchow to beyond Haining, about forty-five miles, there is a broad earth roadway, suitable for riding or even driving, though the latter might be risky, a unique country road. Back of the roadway there is a further embankment some ten feet high and about fifteen or twenty feet thick, which completes the barrier to the encroachment of the boisterous tides. Practically all of the houses near the river are built on levels lower than this bank.

The Haining Pagoda, which has been mentioned already, is apparently not very old and was probably built by a Buddhistic believer in *fung shui* as a protection to the bund and the city against the ravages of the "serpent's head." It is a fair specimen of its class, and certainly forms the most prominent eminence on that section of the wall, and, together with the more recently constructed pavilion just below it, serves well to mark a vantage point from which to view the approach and passage of the wonderful wave which sweeps past at every tide.

A Buffer at Closer Range.



THE BUFFER, OR BUTTRESS, TO THE EAST OF THE HAINING PAGODA, BROKEN DOWN BY THE BORE.

THE BORE

We first witnessed the bore on the night of September 5, 1906, really in the early morn of September 6. Arriving at the pagoda at midnight, it was not long before we could distinguish a distant murmur which increased very gradually for an hour, and was the more im-

FURTHER DETAIL OF THE ABOVE PICTURE.

pressive because nothing could be distinctly seen, the night, though scheduled for a full-orbed moon, being dark and rainy.

After about half an hour ripples and slight wavelets began coming in just as for an ordinary tide in most places, but with greater rapidity and frequency. At 1 A.M. the murmur had become quite loud and amounted almost to a roar with a sort of thumping; presently the very splash of the on-rush could be heard and at 1:15 A.M. a wall of water passed with a speed of about eight or ten miles an hour, and eight feet high, coming almost straight in along the axis of the river, but curving concavely, and with the highest part in the center. After its transit, the roar was soon lost in the sound of the steady rush of water; then huge and rapid waves and swells came in obliquely with great force, striking the wall at about twenty or thirty degrees and generating a great whirl and splash. This lasted about fifteen minutes and then there was a rather sudden decrease in the size of the rollers, the rising water now being increased by more gentle but still very rapidly moving crests. The inflow was still continuing at 2:30 A.M. when, deserted by our native guides, we were forced to return to our little boat in the canal near by.

The forenoon of September 6 was spent in an examination of the sea-wall for a length of some three miles in the vicinity of the pagoda, the results of which we have already noted.

Evidently we were correct in expecting the bore for that day to be a big one, for a great number of Chinese had come out to witness this never-ceasing wonder, and a considerable group had to judge for themselves of the efficiency of our binoculars in extending the range of vision seaward.

Judging from the ease with which the preliminary murmur had been heard the night before, we were confident of being warned of the formation of the bore in plenty of time to watch its formation from the beginning. But curiously enough this premonitory murmur was not anything like as distinct in the daytime as at night, and while closely examining the structure of one of the brush buttresses, we were surprised by the cries of the natives as they descried to seaward the faint white line which marked the birth of the bore. This was at 12:30 P.M. Bringing our glasses to bear on this line which seemed to be near the meridian of Chishan, a conspicuous hill about twelve miles east by fifteen degrees south from Haining, marking the indentation previously referred to as Bore Shelter Bay, we could see that the bore had formed in two branches. The one on the north side of the channel was considerably the larger and was advancing almost directly up the river, touching the sea-wall with its northern end and the sands with its southern extreme; the other branch was approaching from the southeastward and touched the sands on both sides. The advance

line of the first was not so very high, but still we could see it miles away running along the curve of the land, while behind it came a mighty wave, the whole advancing practically at right angles to the northern shore, while the second or southern branch came on almost parallel to the shore and with increasing speed.

This latter line gradually curved around and when about five miles from Haining its northern extreme overtook the southern extreme of the first, thus forming a continuous line of white breakers two or three miles long. Where this juncture was effected great waves, white from the force of impact, dashed many feet into the air in mid-stream and seethed all about the point of conflict. This immense upheaval, however, rather quickly subsided, and the flood wave resumed a more

JUNK ON REFUGE, WHICH IT REACHED ON THE AFTER-RUSH OF A PREVIOUS BORE.

or less uniform height, which presently increased as the bore contracted in width, and increased in speed as it conformed to the narrowing channel of the river.

With rapidly increasing roar and steady progress this line advanced, and the immensity of the phenomenon began to be appreciated even more than on the previous night. A wall of very muddy water, white-crested and fully ten feet high, was approaching with the speed of a railroad train, breaking over and overwhelming the resisting ebb tide of the river, which in front of the pagoda was still running out with a speed of six or seven miles an hour and fighting every foot of the monster's advance. It was a battle of the flood against the ebb, and

the flood, backed by the irresistible power of the ocean's rhythmic pulse, was swallowing up the ebb with an on-rush which must be seen to be fully appreciated.

At two miles from Haining the flood-stream, probably that from the southeastward which appeared to run through the other, charged into the sea-wall, the violent rebound from which caused a tumultuous upheaval of the waters several hundred yards behind in waves twice as high again as the front of the bore.

As the northern end of the bore struck one of the buttresses, its line of advance was deflected and it came on with a curving and recurving crescent front, the ends being thrown forward of the middle

A JUNK REFUGE—THE JUNK SHOWN IN PREVIOUS PICTURES IS LYING ON THIS REFUGE TO THE LEFT OF THE PART HERE SHOWN.

portion by several hundred yards. This deep graceful curve in the line of the turbulent waters was undoubtedly due, aside from the deflection caused by the buttresses, to the swifter current in the center of the ebb, unwilling to the last to admit defeat.

As the bore passed Haining at about 1:45 P.M. it had somewhat the form of a double crescent, over a mile long and eight to eleven feet high, traveling twelve or thirteen miles an hour; its front a sloping cascade of bubbling foam, falling forward and pounding on itself and on the river before it at an angle of between forty and seventy degrees, the highest and steepest part being about six hundred yards off shore over the deep channel of the river. Close by the northern bank or sea-wall the height and rush were not so great because of the projecting buffers

THE SAME VIEWED FROM THE OUTER EDGE OF THE SECOND LEDGE OF THE SEA-FOOTING.

just east of the pagoda, and yet now and again the bore swelled up to the wall as it sped along. The southern end, meeting an incline of sand which rises only nineteen feet in a mile and a half, trailed away in a line of very deliberate breakers, which ceased half a mile to the rear of the bore or where it had passed three minutes before.

A second smaller bore followed directly after the first in the form of a group of secondary rollers on top of the first body of water, and several hundred yards in the rear of the crest behind which for many tens of feet the rushing water was churned into foam by the turmoil. These secondary rollers leaped up from time to time as if struck by some unseen force and disappeared in heavy clouds of spray. These breakers on the top of the flood were sometimes twenty to thirty feet above the level of the river in front of the bore, while the conflict in progress on the river-bed itself was clearly evidenced by the quantities of mud, sand and even large gravel which were seen to be mingled with the surging waters.

The river filled up to the level of the bore soon after it had passed, but not evenly.

A quarter of an hour after the bore had passed Haining, the water had risen thirteen feet; after two hours it had risen eighteen feet; and a high-water mark of nineteen feet was attained at 4:45, or after three hours of flood tide. At this time the stream commenced to run out swiftly. At 6:45 P.M. mean level was reached and at 9:45 it was practically low water again, though the out-going stream continued

to run rapidly eastward until the arrival of the midnight bore, the water being at its lowest for the two hours preceding that event.

One of the most surprising features of the whole phenomenon is the sudden change in the aspect of the river. Just now we saw the muddy bottom bare for some distance from the shore to where the mid-river current was swiftly out-flowing, and a few minutes later the whole basin is filled with muddy boiling water, which seems to threaten to wash away even the substantial sea-wall on which we stood.

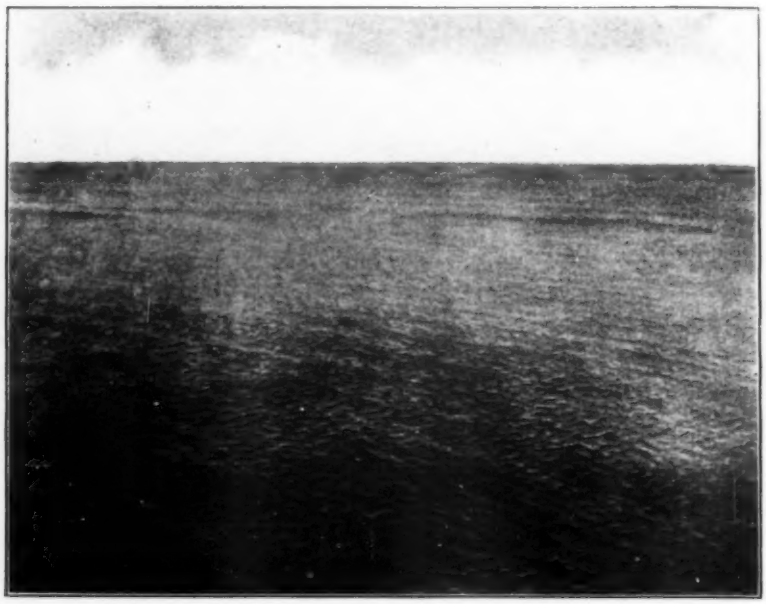
After the passage of the bore and during the in-rush of the after-body a number of men, some of them probably the duly appointed patrols, others not, appeared on the sea-wall with very long bamboos, some furnished with hooks at the end or spikes, some with rake-heads and others with loops of rope, all designed to enable their manipulators to gather in the driftwood, consisting chiefly of the loosened or broken piles of the outer protecting ledges of the dyke. One fellow was seen marching off in triumph with two whole piles and a half.

During and just after the passage of the bore a busy scene was also enacted on board the junks resting so securely on the platform along-

THE SAME JUNK AS IN THE PREVIOUS PICTURE, SEEN FROM THE TOP OF THE WALL.

side the bund and behind the buttress of brush and piles. The bore passed them harmlessly by, merely drenching them with spray. The flood following behind, however, quickly floated them off this place of security, but with a few turns of the ropes, the junks were quickly remoored and continued to ride safely on the racing tide. This accomplished, their loading was hastily completed, and within an hour they were away for a fresh destination up stream, or, waiting two hours longer, were able to effect an outward passage.

It was a curious sight to see the other junks, which previous to the formation of the bore were sheltering in Bore Shelter Bay or behind the islands out beyond the mouth of the river, come riding swiftly



ASPECT OF RIVER TWO MINUTES BEFORE THE ARRIVAL OF THE BORE.

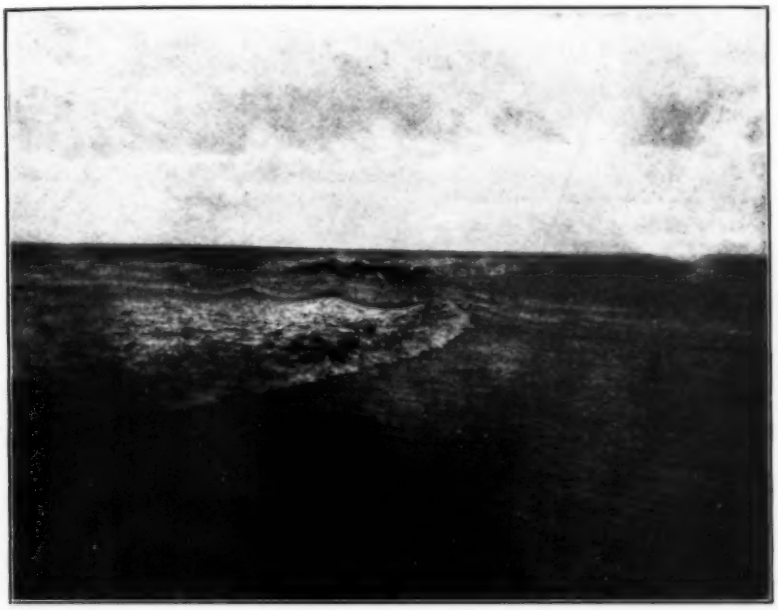
in amid the after-rush, past Haining toward Hangchow, with all sails set but with their bows in every direction. On the days we observed there were each time a baker's dozen of them, but sometimes as many as thirty junks may be seen utilizing tidal energy for ascending the river at a speed exceeding that of an ordinary steam vessel of equal size. As soon as they could steer a little, they made for the shelters behind the buttresses, where they allowed themselves to be stranded by the falling tide.

Steam vessels, not being able to follow the junkmen's method of avoiding the difficulties of navigation, can not use the river. The imminent danger to which those attempting it would be exposed might be inferred from the description we have given, and is clearly shown

by the report of Captain Moore, R.N.,[4] who in 1888, in command of H. B. M. ship *Rambler* and two auxiliary craft, undertook a thorough survey of the river and estuary, which he continued in 1892, and whose vessels narrowly escaped total wreck.

The Birth of the Bore as shown by Observed Water Levels

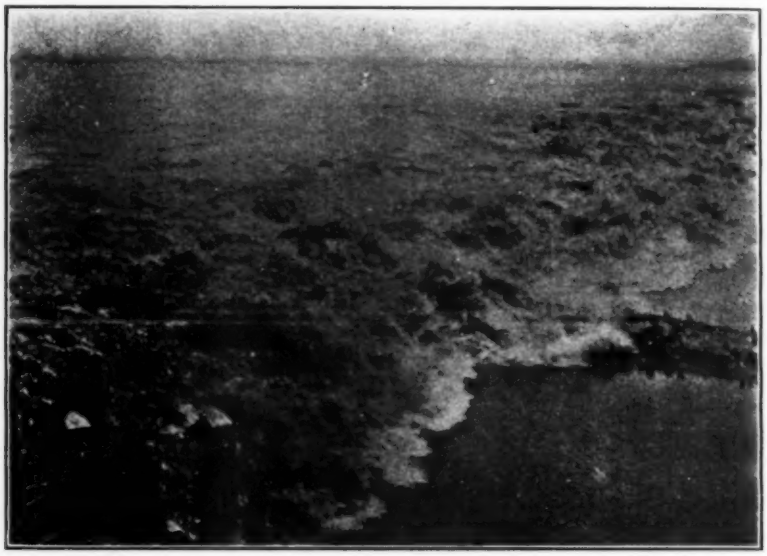
In this survey observations of water-level were taken simultaneously at three places: Volcano Island, away out at the mouth of Hangchow



Aspect of the River at the Same Place as the Last Picture, and Only Two Minutes Later. Wave Ten Feet High in the Center.

Bay; Rambler Island, fifty-one miles farther in; and Haining, twenty-six miles up the river. These measurements exhibit the nature of the bore very clearly. At 8:30 P.M. the water was one foot below mean level at Volcano Island, twelve feet below at Rambler Island and eight feet below at Haining. Thus the water sloped down from Haining outward to Rambler, and also downward from Volcano inward to Rambler; the water was running up the estuary toward Rambler Island, and down the river to the same point. By 9:30 there was no great change, but the water had risen two or three feet at Volcano Island and at Rambler Island. By 10 o'clock the level was rising rapidly at Rambler, so that there was a nearly uniform downward slope

[4] "Report on the Bore of the Tsien-Tang-Kiang," London, 1888. "Further Report," etc., 1893. Also, in *Proceedings of the China Branch of the Royal Asiatic Society*, 1888.



BORE FRONT, THIRTY FEET HIGH, A FEW MILES BELOW HAINING.
(Negative of John Green, Esq.)

from Volcano Island inward to Haining. The rise at Rambler then continued to be very rapid, while the water at Haining remained nearly stationary. This state developed until midnight, by which time the level had risen twenty-one feet at Rambler and about six feet at Volcano, but had not yet risen at all at Haining. Through all this interval the water was running down the river from Haining toward its mouth.

This state of strain represented by a difference in level of over twenty feet between Rambler outside and Haining only twenty-six

THE BORE PASSING HAINING.
Negative of C. Pape, Esq., Hanchow.)

miles farther in could not last long, and shortly after mdnight the strain broke down and the bore started somewhere between Rambler Island and Kanpu, and rushed up the river in a wall of water twelve feet high. Following the bore came the after-rush which carried the level up eight feet more. It is on this that the junks are swept up-stream as already noted. At 1:30 the after-rush ceased, but the water was still somewhat higher at Rambler than at Haining, and a gentle current continued up-stream. The water then began to fall at Rambler, while it continued to raise at Haining up to three o'clock, when the ebb set in. On the south bank, at any rate, for four or five miles inside the mouth of the river, the stream commences to run out strongly an hour before high water at Haining. The fall of the water in the ebbing tide is not particularly interesting, for there is no bore down-stream, although at one time there is an exceedingly swift current.

According to the reports of others, the height, speed and characteristic appearance of the bore's front are maintained for fifteen miles above Haining, after which the height decreases; and the wave passes Hangchow city about an hour and a quarter after passing Haining, soon after which it breaks up and gradually disappears, though an effect is reported to be felt at times at Yenchow, some forty miles farther up the river. At Hangchow the rise and fall does not exceed six or seven feet. At Haining, as we have seen, the flood usually lasts three hours; the ebb, nine. At Hangchow the flood continues for only one and a quarter hours and is nearly all in the bore proper.

When the moon is at the point in its orbit nearest the earth at the same time that it is full or new, or when there are strong northerly or easterly winds in the Chusan Archipelago, the bore generally arrives early off Haining, travels at a greater speed than usual, and is also higher. Natives have reported tidal waves at Haining with a height of over thirty feet. As we have already noted, the highest bore is generally expected on the eighteenth of the eighth moon of the Chinese calendar.

Chinese Fancies concerning the Bore

An account of Chinese fancies concerning the tides in general furnished by Professor Giles, may be found in Professor Darwin's book already referred to, and Captain Moore in his report notes a curious legend which ascribes the origin of the bore to the revengeful workings of the spirit of a certain popular general who was assassinated by the Emperor through jealousy of his growing power, and whose body was thrown into the Ch'ien-tang Kiang. Later the Emperor sought to check the devastation of the country which arose from this source by making appeasing sacrifices on the sea-wall; but without effect, and

it was at last decided to induce good *fung-shui*[5] by erecting a pagoda where the worst breach in the embankment had been made. This is the pagoda already frequently referred to and which is still in good condition. "After it was built, the tide, though it still continued to come in the shape of a bore, did not flood the country as before."

Fanciful as these ideas are, it is not at all surprising in view of the awe-inspiring phenomenon which recurs at every tide, and with which the inhabitants have had to cope perhaps from time immemorial, that they should think of it with reverential superstition as the head of a monster serpent which must needs be appeased. As many as five or six thousand people have sometimes assembled on the sea-wall to propitiate the god of the waters by throwing in offerings at a time when the serpent under his control was raging at its highest.

Intermittency of the Bore

This legend taken in connection with the fact that Marco Polo, who in the thirteenth century spent a year and a half in Hangchow, does not include in his account, which otherwise pretends to great minuteness, any reference to the bore seems to Professor Darwin to indicate that the bore is intermittent, because the Emperor referred to is of undoubted historical existence and antedated Marco by some centuries. But Marco Polo's accounts are not to be taken entirely at their face value as to accuracy and faithfulness, and even if the bore did not exist in his time, the great sea-wall which was in all probability built when the Chinese historians claim it was built by Prince Ch'ien, viz., 911–915 A.D., must have existed, and it is hard to conceive how he should have failed to mention such a stupendous public work, especially when he seems to have been so keenly interested in the Grand Canal. Either, as some authorities suggest,[6] Marco Polo never really visited Hangchow, but got his glowing account of the city's wonders from some native poet without admixing the proverbial grain of salt; or else he was so enamoured with the gayeties of life at the capital that he could not spare the time to visit Haining or the lower estuary in person, but judged from afar that there must have been much shipping there, for to this he alludes in several places.

As Professor Darwin finally concludes, it is very uncertain whether the Hangchow Bore has been intermittent, but it is sure that it is liable to considerable variation, for reports by the foreign officers who headed the troops sent against the Taiping rebels show that the intensity of the bore was then (1852–1864) far less than it is to-day. The ex-

[5] *Fung-shui*, literally "wind-water," a much-used term in Chinese geomancy, signifying propitious influence of the controling spirits involved in any undertaking—perhaps the nearest simple English equivalent is "luck."

[6] Decennial Reports, Chinese I. M. Customs, 1892–1901, Vol. II., p. 4.

istence of the bore as well as its fluctuations probably depends on a nice balance between various factors, and the irregularity in the depth and form of the estuary renders impossible the exact calculation of the form of the rising tide. The heading back of the sea water by the natural current of the river, and the progressive change in shape of a wave advancing into shallow water, may combine to produce a rapid rise of the tides in rivers. "But the explanation of the bore as resulting from these causes is incomplete because it leaves their relative importance indeterminate, and serves rather to explain a rapid rise than an absolutely sudden one." "It seems impossible from the mere inspection of an estuary, to say whether there would be a bore there; we could only say that the situation looked promising or the reverse." ". . . as in many other physical problems, we must rest satisfied with a general comprehension of the causes which produce the observed result." The description we have attempted may serve to give those who have not seen such a wonder some idea of the really marvelous phenomenon, but the best way to become familiar with its characteristics is to go and see it for yourself.

RAILWAY ACCIDENTS AND THE COLOR SENSE

By Professor GEORGE M. STRATTON
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IN considering whether some of our frequent railway accidents may not be due to the character of the signals we employ, it should be borne in mind that these signals often must be caught and instantly translated into action under conditions of uncommon mental stress. And for this reason, defects of the symbols which might otherwise be far from serious do now become of vital moment. Yet it has been said that the work of the locomotive engineer seems to the observer more difficult than it is—that the long training through which these men must pass permits them to carry lightly their great responsibilities. It was the more interesting, therefore, when, on an express-engine not long ago, we had come to the end of our long course, and the din and jostle had given way to calm, to hear the engineer speak of the tension of his work. He had been at the throttle but three hours that day, and after going for a time to the round-house, would take his express back over the same run that night. "My partner," said he, "will have the run to-morrow. No man could stand it, holding her down in this way day after day." And so the engine crews on such a swift express lie off alternate days, and the engineer and fireman may not take out their train unless the entire preceding day has been a day of rest. Such carefulness on the part of a great corporation calls for praise which should be all the less restrained when so much must be said to-day of the shortcomings of our railways. Yet there could hardly be stronger proof of the strain under which the engineer must labor; for no company would give to its hardy servants every alternate day for freedom, unless experience had taught that the service itself required it.

Nor is it difficult to appreciate in some measure the severity of the work. Various duties that on an ocean steamer are distributed among helmsman, lookout, engineer, and the officer on the bridge, here fall chiefly upon a single man, and this where the care and instant judgment required seem at times to be not far below those needed for the guidance of a ship. The locomotive engineer must control a marvelously complex and ponderous piece of mechanism, keeping his sight and hearing and sense of shock so alive that amid the universe of whirl and glare and explosive rattle in which, for the time, he is centered, he can detect the foreign note or quiver that speaks of disarrangement.

He must know that his outside lights are burning bright, that the water in the boiler is sufficient, that the air-brakes are in perfect working. He must from moment to moment glance at the hands of his watch, and must know exactly where he is upon the road. And yet all the while his eyes must hardly be taken from the darkness into which his engine rushes, to catch the first glimmer of the signal which is his guide.

Since the safety of many lives thus depends upon these signal lights and upon their sudden clearness to a mind that must attend to many things at once, the symbols should at all times be the least ambiguous that can be planned. Yet the present night-signals, given by colored lights beside the track—upon many roads, white for "safety," red for "danger," and green for "proceed with caution"—are open to grave objections. For the human eye at its best and without abnormality is liable to mistake the signal hues at night, especially when the outward conditions are anywise untoward, whether by the distance or the low-burning of the lamp, or by fog or smoke or storm. And even when the colors are perceived with perfect accuracy, the use of the common oil-light called "white," as one of the signal colors, throws a dangerous task upon the engineer, inasmuch as it requires him to take constant heed lest he regard some window-lamp, or other meaningless light along his course, as a sign that all is well, and in consequence rush onward to his train's destruction.

That objections of this character are supported by strong evidence, and are not of merely theoretical importance, but are connected with actual and known disasters—to make this clearer is one of the main purposes of the present paper.

In regard to the use of white as part of the signal code at night, the danger from this source has long been recognized by leading signal engineers, although in spite of this recognition its use continues on a large number of our American roads. It is not many years ago that an accident occurred at Whittenton Junction, Massachusetts, from this very cause. The engineer mistook a lantern hanging from the gate at a street-crossing for his safety signal, and crashed into another train. More recently, Mr. Baggett, of the Galveston, Harrisburg and San Antonio road, has given an instance where disaster resulted from the use of white. The railway signal, in this case, was exactly in line with a light shining from a high bay-window; and when the signal light itself one night was out, the engineer mistook the light in the window for his signal, and a serious accident was the outcome. And other cases are reported by the Interstate Commerce Commission. A switch light happened one night to be extinguished, and the engineman "failed to notice the absence of the light, being deceived, he says, by lights in the vicinity"—a deception which brought damage amounting

to $3,500, a maiming and a death. On another occasion an engineman runs past a signal which the station agent declares was set at "stop," but which the engineer himself asserts was showing "clear." Immediately after the passage of the train, the signal light was found to have been extinguished, as it had been once before that evening; it is not improbable, therefore, that the "clear" light which the engineer saw was some neighboring light which he took to be his signal. His mistake brought death to 18 persons, injury to 57 more and a loss of $15,720.

With this evidence of the danger which lies in using white for color signaling, and before passing on to consider red, a word should be said of green—a color which, partly by its strong contrast with red, its companion in the system, has found most wide acceptance. Green stands out distinct from the common lights of street and house; it readily makes an impression upon the normal eye. But persons who are not color blind are liable to be weak in their sense of this very color. And smoke, one of the great disturbers of signals on the railway, has a serious influence upon green. For smoke, which makes white or yellow lights look red, does this by making ineffectual the very rays that are so important for giving a green light its greenish cast. The simple experiment of holding a smoked glass before a green railway-light will easily show how hostile smoke is to the passage of green rays. Now when, for this or any other reason, green comes dimly to the eye, especially when sight has grown accustomed to the dark, it has the misfortune of appearing, not green at all, but a pale and ambiguous light that is indistinguishable from white. Under such circumstances, especially upon those roads where both white and green are signal colors, the danger of their confusion is not imaginary; nor is the danger of green's total obscuration slight. In the records of the Interstate Commerce Commission occur more than one instance where the failure to observe at night a "distant" or "caution" signal, which is often green, has been an important part of the cause of fatal accidents.

But after all, the core of the present system is red, and to this our main attention should be given. The color is usually obtained by bringing before the semaphore lamp a glass which, acting like a filter, permits the passage of those rays that are red or reddish, and holds back from the eye all other light. Such a ruby glass, by killing off in this way all that portion of the flame's light which is green or blue or violet, and often all that is yellow, does of necessity greatly reduce the brightness of the signal, leaving it in many cases about one fifth as intense as when, by the signal mechanism, the red glass is removed from the front of the lamp. This readily explains—what any one can observe—that in a cluster of signal lights equally remote, the white signals normally outshine to a marked degree the neighboring signals

that are red. This, of itself, is an undesirable condition, since the sign of danger should of all be most outspoken.

The disadvantage under which the red danger signal labors is, however, quite insufficiently expressed by saying that the ruby glass often virtually destroys fully four fifths of the light from a lantern flame already none too bright, and to this extent increases the liability that the most momentous of the signals will at some crisis be seen too late or not at all. Even the remaining portion is often far less effectual upon the eye than its physical quantity would lead us to expect. The importance of the matter for signaling will perhaps justify some further account.

If, by reliable devices of the laboratory, a semaphore light showing "white" be gradually reduced in brightness, a point can easily be found where the eye, grown accustomed to the dark, can just perceive the light. And when for comparison a railway ruby glass, or "roundel," is placed before the lamp, the observer now obtains no conscious impression at all. But instead of having to increase fivefold the brightness coming through the glass (as one might expect, knowing that the red glass is pervious, say, to but one fifth of the light of the flame), it is necessary to increase it no less than fourteenfold. Such an increase is the least I have found necessary when experimenting at night over a stretch of more than four thousand feet and when smoke gave a relative advantage to the red. Within the laboratory the red has never been perceptible until the light was increased eighteen times the brightness required for white. Such, however, are the most favorable experiments, and are by no means average ones. On the average it is necessary to increase the light as much as thirty times before any conscious impression at all is made by the light through the red glass. One of the subjects of this experiment—a man who would pass the usual tests for color-blindness—has still remained insensible to the red when the light is increased to seventy times what is needed for the white! Such facts as these show clearly that by merely looking at a cluster of railway signals, or even by taking the usual tests of their relative intensity or visibility when shining bright, we get no adequate idea whatever of the difficulty which the eye has with very *feeble* reds. And feeble reds are no great rarity in the actual conduct of trains. The many influences which render signal lights obscure thus act with a peculiarly fatal force upon the very color which is our chief reliance for the protection of life.

And the doubt thus raised regarding red is not allayed by the reports of railway accidents. For in these reports the frequency with which engineers fail to observe red signals at night is a most impressive fact. It is often impossible to tell assuredly why men at such times are unconscious of the danger sign; but even when allowance is

made for the sheer carelessness of trainmen, or for exhaustion resulting in their sleeping while still on duty, there seem to be cases enough to warrant some suspicion of the virtue of the danger signal itself. In the summer of 1904 an engineer at night ran past signals at "stop," and into an open drawbridge with his train. About a year later, a disaster was caused by the failure of an engineer at night to heed two block signals and a flagman, the engineer himself losing his life by his mistake. On still another occasion, a train ran past three or four warning red lights, and by a collision with a passenger train ahead brought death to 23 persons, injury to 85 and a property loss of $7,000. And the inherent difficulty of perceiving weak red may have been a contributing circumstance to that wandering of the attention of an engineer who recently, after passing a "distant" signal obscured by smoke, failed to notice "until he was quite near it" his "home" signal telling him to stop, and crashed into the rear of a passenger-train. This failure to see in time the warning light cost seven lives, brought injury to no less than 142 persons and destroyed property amounting to $44,000. And finally, on the night of December 30, 1906, a collision occurred in the District of Columbia, due in part to the failure of an engineer to see a red light obscured by fog; and in this disaster 43 persons were killed, 63 were injured and property valued at $16,000 was destroyed.

These fearful results, depending, as they do, upon the failure to see red lights, diminish greatly one's confidence in this color. And this confidence grows still less as we bear in mind the many instances, which have not been adduced at all, of utter failure to observe the red "tail lights" of trains, red switch lights, or red hand lanterns—failures that ended in deadly accident. The insufficiency of a red hand-lantern carried down the track for the protection of a standing train is doubtless in part to be ascribed to the unexpected place in which these signals must of necessity be shown, and the engineers' unreadiness to note them; but it is not improbable that the very color of the signal contributes to its failure. We are accustomed to think of red as exceptionally impressive; and it truly is in many respects an effective light, attracting the attention when once the eye catches it in strength. But at degrees of illumination that would be ample for some of the other colors, it cease to penetrate the mind—somewhat as in photography, red of all colors has least effect upon the sensitive plate. Red may some day come to be regarded as a danger signal, with an unusual meaning to the words. And yet, taking all things into consideration, it is perhaps the best color to use as a sign of danger, if color must be used. Such a conclusion, however, reveals but too clearly the weakness of a system based on color—reveals how fatally mistaken it is to make the life and safety of passengers dependent upon the hurried

recognition of colors at night by any man, above all by a man who has many and most insistent duties besides.

That the color-sense is wholly unfit for the office it holds in railroading is hardly open to any doubt whatever. One must speak with less assurance, however, as to what should take its place. But even here the general principle that might guide the change is reasonably clear. Our eyesight detects two different features in objects—their color and their spatial character, such as shape, position and movement; and the sense of color is far less primitive and vital and masculine than is the rude sense of space. Nature seems to have held the sensitivity to color a cheap and slighted accomplishment, to be crowded out or postponed to the mere finishing school, like young ladies' French and dancing. But the rugged feeling for place and direction is early given and pressed deep until it becomes a central fact in self-preservation and advance.

Now if the eyesight of the engineer is to be depended upon at all, it is this more fundamental and stable portion of it that should be given responsible work. If the practical difficulties could easily be met, the power to distinguish between rest and rapid movement of some conspicuous object would be the best to call upon in signaling. For we, like the bird and beast in the woods, are alive to slight quick movements in the field of view, far more than to color or even to shape and size. When the arms are waved or a lantern swung by hand to attract attention, appeal is instinctively made to this deep and primal interest in moving things. But next to this, the simplest and least erring of our visual perceptions is of large differences like that between a vertical and a horizontal line or one aslant. Now these rough and simple elements are precisely those used for the day signals of most block systems, where there is an extended arm placed high beside the track, and its direction of pointing—up or down or at some angle intermediate to these—tells the engineer whether the track ahead is open to him or closed or to be entered only with caution. Such signals make no prime appeal whatever to the sense of hue, but only to the sober feeling for visual place. And there seems to be nothing to prevent that this same principle of signaling should be carried over into the night and be even more successful there. For the extended vane used for the day signal often is before some unpropitious background of buildings or of trees against which it stands out in no strong relief. But at night it would be possible to use some self-luminous line of light that would appear sharp and unmistakable against the dark.

The detailed mode of applying such a general principle belongs to mechanical art rather than to psychology. But lest the principle itself should be misjudged for want of some more definite form in the mind, it might be well to imagine a row of incandescent lights inserted in the signal-arm now used by day, but lengthened and otherwise modi-

fied in whatever way its new work might require. Considerable intervals may be between the lights, and yet from a distance they will seem a continuous line; and as for length, experiment both in the laboratory and over a distant stretch at night shows that the main directions of such a line can be caught by the normal eye when the length is about a thousandth of the distance from which it is to be read. Three or four lights in a row about five feet in length would thus suffice for giving an engineer his signal a mile before he passed the post. A space signal given in some such way would naturally require more feeding of electricity or gas or oil—than does the single small wick flame that now gives forth the colored beam. But on the whole it would perhaps be well to spend fuel and light rather than life.

The mere imaging of a generous and glowing line to give the signal, will at once quiet some grumbling doubts that come from failures hitherto. Certain older attempts to use the space principle for railway signals at night could easily bring misgiving if the real cause of the failure had lain in the space sense itself. But, in fact, there has been no readiness to use the amount and extent of light needed for a proper signal. One of our roads tried to guide its trains by means of two lights whose changing position with reference to each other should give the sign to the engineer; and this signal was found unsatisfactory because these two lights blended into one when looked at far away. But for the most part the attempts have been confined to spreading out into a band, by means of a reflector, the light of a single lamp—a band of light that was too faint to be well seen when the reflector became dimmed by smoke or the corrosion of the weather. Such crude attempts to make a spatial signal were of course foredoomed to failure, and give no reason to distrust the perception of space itself. They simply prove that sufficient brilliancy of light must be maintained, and that this brilliancy must be stretched to sufficient length—conditions which can certainly be fulfilled at least wherever there are electric lights.

One can speak with greater confidence because of the practical success of such spatial signals in another field. The use of the luminous line is already well established in the navy. Two movable arms, each provided with a row of incandescent lights, here rapidly convey, by the direction in which they point, their message from ship to ship, or to the shore. And even with comparatively short lines of light, their position is legible by the unaided eye at a considerable distance. The outcome here gives ample reason to believe that it would be possible to apply the same general method to the railway service.

The advantages of relying on our space-perception instead of on the color sense will probably in time be recognized as far outweighing whatever difficulties there may be in the change. The new plan would

merely require us to suppress the worse half of the present composite set of block signals—the half, which relies on color—and to render universal its better portion which already signals by direction. The present system would thus be simplified and fulfilled, rather that annulled, and there would be no need of training engine drivers to an unfamiliar code. And while the perception of the trend of a line of light requires that the refractive power of the eye shall be normal or shall be corrected by the use of glasses, the engineer's work even now demands that his spatial vision shall be keen, and thus no innovation would be made.

But even were there many objections to the use of spatial signals, they must be grave indeed to outbalance the fact that a line of light not only frees us from the treachery of the color sense, but gives a symbol that is distinct from the usual lights of the window or the street, and at a stroke renders well-night impossible those accidents that come from mistaking foreign lights for block signals. Moreover, we should then have a system wherein danger would be indicated at all times as clearly and as unmistakably as safety, whereas in the present code the red danger signal can too readily remain unseen. An important advantage besides would be that signals of the kind here proposed could hardly, by influence of smoke, or fog, or storm, be made to seem the very contrary of what they really were. A green light may look whitish, or a yellow light red, by mere conditions of the air. But a vertical line can not well be made to appear horizontal, or a horizontal diagonal, by smoke or fog. Its message might be cut off entirely, but could not readily be distorted into its fatal opposite. In this, as in so many other ways, a change of usage commends itself to the critical sense.

In urging that we no longer rely upon the color faculty for the safety of our trains, I have spoken almost exclusively of those difficulties which color offers to eyes that are entirely normal and sound. And upon such facts the main objection to the present system may well be based; for they are strong enough in themselves to condemn our usage and to demand that it be changed. But the reasons so far given are immeasurably strengthened by the existence of color-blindness and other defects of the sense of color. There are some men, it is true, who believe that the danger from this source is entirely averted by the current examination of engineers. No one would wish needlessly to lessen faith in such examinations. And yet it should be more widely known that defects of color vision are not always easy for physicians to detect; far less are they for laymen. And since many dangerous cases are known to slip through the meshes of medical examiners elsewhere, it is reasonably certain that the same is true with us. Dr. Stadfeldt, of Copenhagen, in a recent examination of 295 pilots (who, like engine-

men, must distinguish colored signals), found 17 who were defective in their color sense. And Professor Nagel, of the University of Berlin, one of the great authorities in this department of research, and who has been called upon to assist the Royal Prussian Railways, has lately found in responsible positions like those of engine driver, fireman, switch tender, no fewer than twelve typical instances of red-green blindness among men whose sense of color had been officially tested and approved *four or five times.* Of about 300 employees of all branches of the service, all of whom had been tested at least once—and almost all of them more than once, by physicians and not by mere laymen—Nagel reports five per cent. to be typically color-blind; not color-weak merely, but actually color-blind. It is, therefore, difficult to partake of that happy confidence expressed by one of our leading railway journals, that "the railroads have long since done away with the dangers of color-blindness, by taking color-blind men off from their engines." We must, on the contrary, believe that the undiscovered presence of color-blind and color-weak men upon our engines adds to the many reasons for refusing longer to intrust the safety and life of thousands to one of the most fickle of our human faculties.

THE INFLUENCE OF TECHNICAL SCHOOLS

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THE increasing strength and efficiency of our applied science schools presages a period of industrial prosperity, marked not only by pecuniary profit to merchants and manufacturers, but also by the constantly improving condition of wage earners. But there are those to whom this prospect brings no comfort, for they see in it the foreshadowing of a period marked by decay of philanthropy and lack of piety, when a materialistic spirit will bring about a selfish individuality destructive of all that is good in society; they see its baneful influence already here, for young men avoid the college courses and rush into applied science to reach money-making as soon as possible; while not a few of them denounce the modernized curriculum in colleges as the disturbing cause and plead for restoration of classical studies to their former preeminent place as an all-important means of defense against the approaching calamity.

Those who have struggled to free the curriculum from medieval shackles would have no cause for mortification if they were responsible for the increasing attendance at schools of applied science; unhappily, they can lay no claim to the credit, since the matter in no wise concerns the contests between classicists and anti-classicists. Existing confusion respecting this matter is due largely to gradual development of the technical school within the college. Even now in the smaller colleges, applied science courses are parallel with those in pure science and in literature; students in all alike meet in many classes, assemble in the same chapel, mingle on the same campus; graduates in applied science receive the degree of bachelor in science as do college students taking pure science, and think of themselves and their fellow students think of them as having graduated from college. The confusion would have been less pronounced had there been a proper difference in degrees.

For, be it understood, the college and the applied science school are wholly different in character and purpose. The latter is a professional school, and its graduate has never been "at college," though he may have received a superior intellectual training and may have become in many ways a stronger, broader man than his friend of equal ability, who has B.S. or A.B. from some college with a narrow group or wide elective system. The applied science school is professional as are schools of

law or medicine and differs from them only in that the essential prerequisites for admission are necessarily much higher.

The assertion, so often made, that young men are deserting the college courses is not well founded. Comparing the college catalogues of to-day with those of thirty-five or almost any other number of years ago, one finds that there has been no falling off in proportion of students taking college training—on the contrary, the number has increased far out of proportion to increase in population. In looking over catalogues of law and medical schools one sees that, among American-born students, the proportion of men with college degrees is much greater than it was thirty-five to fifty years ago.

But whence come the thousands of students taking the technical courses? In not a few instances, no doubt, they are sons of men disgusted with the wide elective or the narrow group systems prevailing in colleges; men, who, desiring to secure for their sons a broad training without reference to their future work, find themselves compelled to choose between narrowness and breadth, between college and applied science. They choose the latter even at the risk of failure to acquire some special forms of culture. In other instances, they are sons of intelligent men of moderate means, who have read addresses by university presidents and have noted the university methods. They have seen that in some institutions the fourth and even the third year were lopped off from the college course and that, in their stead, study for a professional degree was accepted as qualifying for the college degree. It is but natural that thoughtful men, unfamiliar with educational affairs, should accept the opinions of those popularly recognized as authorities in such affairs. They are the more inclined to this in view of the unjustifiably long period required by secondary schools for college and science preparation; and the conclusion is confirmed by the discovery that, in applied science schools of the higher grade, much is taught that is given in the two college years, which all agree are essential. Students belonging to these two classes are increasing in number, and they will continue to increase as long as the college curriculum remains in its chaotic condition; but they are still an insignificant minority. Comparatively few parents know enough to make intelligent choice for their sons, and most men, with means to give their children the luxury of a college education, prefer to have them follow the beaten track.

The overwhelming majority of students at applied science schools belong to a wholly new class. As has been said frequently, the sudden discovery of our country's resources, forty years ago, made necessary new types of training. The old-time country surveyor had laid foundation for lawsuits in important cases; the excellent pit-boss failed as superintendent of mines; the rule-of-thumb graduate from the cast-

ing-house was a source of disaster in furnaces; while merely "practical men" were helpless before the great problems in railroad and other types of civil engineering. There was room no longer for uneducated surveyors, founders, superintendents, engineers. The skill demanded under the new conditions converted those "callings" into genuine learned professions, and schools of applied science were established to fit men for them. Most of the students in those schools, now receiving advanced education, can not afford the luxury of a college education course, and their increasing number is due simply to the great demand for trained men in subordinate as well as in responsible positions.

The assertion that men go into science for the money that is in it is merely a variation of the refrain with which the writer was familiar during his early student days, fifty years ago. Then, the attractions of business were the vile bait which lured men from the supposedly unselfish pursuits. But the plaint is unworthy of the men who make it. Students go into science as others go into law, medicine, or at times, even into the ministry, for the "money that is in it"—that is, to gain a livelihood in an honorable way. If a graduate in applied science have great energy, common sense and executive ability, the combination of business capacity with systematic training may put him eventually into a position of great responsibility with corresponding salary; but if he must follow his professional work alone, the prospects of acquiring a competency are about as good as those of the average clergyman.

It is unfortunate that our colleges have not made clear differentiation between students in culture and students in applied science. Failure to do this has brought about the tendency to confound pure and applied science, college and professional work, which is shown by many college graduates. If one recognizes this fact, he will be less surprised at the frequency with which technical schools are dragged into discussions respecting changes in the college curriculum. An excellent illustration of the tendency referred to appears in an address delivered at the inauguration of a college president a year or two ago. The speaker pled for classical training, as a classical college "is the best place in which to keep alive the heroic ideals of self-sacrifice and service." He said:

> It was urged when technical education began to be largely developed in our land and the classics were cast out from the training of young men and women —it was urged that this new kind of training in the precise and mathematical sciences would breed men of firmer principles. The technical schools of our land have not turned out men and women who see moral issues more precisely or who live more faithfully for the right things on earth than the young men and women who have had their education under classical influence. And the influence of our technical schools not alone has not bred firmer principle, but it surely has not bred finer sentiment.

And the proof of all this lies in the fact that the speaker had sought unsuccessfully in several technical schools for a man willing to teach mechanical and electrical engineering under missionary auspices in a foreign land. His argument was strengthened by the assertion of one president that the young men in his institution were not in engineering for the good they could do in the world, but for the amount of profitable employment they could secure for themselves. And the survey of conditions led to this forecast:

> I believe we are going to have to face in this land that inevitable result of our technical education. We have turned away young men and some young women from the great classical ideals of self-sacrifice in fields where they could do the most unselfish work.

These statements, made in all sincerity by one who is respected by all who know him, appeal directly to the prejudices of many who wish well to all mankind; but they are defective and the defect arises from confounding things wholly unlike and unrelated.

Technical schools are not schools for the study of science, but schools in which the principles of pure science are applied to practical operations. Like trade schools, schools of law or medicine, they are to prepare a man to earn a livelihood in honest and honorable fashion, to do well that which formerly was done in slipshod fashion. Mental and moral training, as such, have only incidental place, yet such training is as inseparable from their work as muscular training is inseparable from apprenticeship in blacksmithing. When one considers that students in such schools are taught to regard theirs as professional work of the highest grade; are taught to regard honorable dealing as the foundation stone of a successful career; are trained from the outset to recognize the great responsibility awaiting them, in that the security of vast properties and the safety of communities will depend upon their skill, accuracy and honesty; he can not doubt that even the coarse fiber of an unscrupulous man will undergo some refining during a four years' course. And the facts amply confirm the *a priori* conclusion. The writer knows that the moral standard among engineers of every type—chemical, civil, sanitary, electrical, mining, mechanical—is immeasurably higher than in the days when there were no technical schools, when the work of such professions was left mostly to mechanics. If the standard of professional honor were not high, very high, our national prosperity would come to an end, for all depends on the engineer.

There is no room for pessimism here. Men should thank God and take courage for the future as they see the influence of technical training, which has transformed the face of the world and led to increasing recognition of unity of interest. Improvements in mining and metallurgy have brought about improved methods of transportation and

have cheapened products everywhere, while increasing the rewards of labor; the beef of our southwest and the wheat of the northwest can be sold in London at profit to the producer, and famine in any part of the civilized world is almost impossible; the coal of southwestern Virginia has been sold in Boston at profit for less than the freight to tidewater, thirty years ago, when the transporting companies were losing money; improved methods of refining petroleum have reduced the cost of illuminating oil to a small part of the price of thirty-five years ago, have carried light literally into the dark places of earth, have lengthened man's day by three hours and have given to agricultural communities a social and intellectual life previously impossible; mechanical and sanitary engineers have made possible the compulsory introduction into tenements of comforts and conveniences which, half a century ago, were considered luxuries even in the homes of the wealthy. These and a multitude of other changes for the better, due to men trained in applied science, for the most part in schools of applied science, have in very truth brought the ends of the world together and given us a better sense of the brotherhood of man. One may look forward confidently to the time when bricklaying will be as dependent on scientific principles as brickmaking now is, when the laborer will be a skilled workman and the mechanic a graduate of the schools; when in all our literary institutions training in every department will be supplemented by drill in the scientific mode of thought, that men may be taught how to make inductions safely.

That no young man was found anxious or even desirous of spending his life as teacher of engineering at meager salary amid undesirable surroundings, practically without any reward except that of a good conscience, is not surprising. There would have been ground for surprise if one had been found. No doubt similar success would have attended a hunt among law schools. It is probable that not more than a few score of persons had ever heard that teaching of engineering is a part of missionary work, and it is equally probable that no one, aside from the few score, had ever thought of it as a possibility any more than that of teaching American law. It might have been equally difficult, prior to the establishment of medical missions, to find volunteers in a medical school.

Men, desirous of spending their life in work merely for the good they may do or who are willing to devote themselves to their work for the work's sake, without reference to their own future or to that of their families, be they geologists, ethnologists or missionaries, are very few—and one may say, that, all in all, it is well for the race that the number of such self-sacrificing men and women is small. Persons of that type choose some course which will lead to the attainment of their object. Those desiring to be missionaries take either medical or theo-

logical courses, for along those lines missionary work is pushed, and the workers receive the reward which they regard more than they do money. When shopwork and engineering come to be held in high honor among missionaries, the technical schools connected with state universities will have their share of men preparing for usefulness. When that time arrives there will be no more insinuation that the technical school lessens respect for principle and weakens fineness of sentiment. At the same time, it may be remarked that labeling a man as selfish or without the finer sentiments, simply because he is unwilling to become a foreign missionary, seems to be a somewhat audacious assumption of the Divine prerogative.

But how does this question of the technical school concern the observance or neglect of classical studies in the college course? Not in any wise. Classical studies have not been thrust out of the technical school, for they never were in it; they have no proper place there any more than in schools of law or medicine. Whether or not prolonged classical training is desirable for those who can afford the college course prior to beginning preparation for life's work is certainly deserving of serious consideration; and there must be much to be said on both sides—otherwise, the discussion would not be intense as at present. It may be that classical training, as imparted in American colleges, is the best or even the only means of turning the youthful mind to high ideals—but the writer hesitates to accept the proposition. He underwent a very severe course of classical training from his sixth to his twenty-second year, yet his memory, by no means frail, does not recall "the great classical ideals of self-sacrifice" with which, one must suppose, modern ideals fade into insignificance. Nor has this conception of classical training been accepted always as axiomatic. The writer remembers an earnest discussion by several professors of theology at his father's table, about fifty-five years ago, in which those excellent men lamented the degrading influence of the classical authors read in college—the same, by the way, as those read now. And doubtless some of those reading this article will remember the efforts made by good men to counteract this evil influence by the preparation of works in classical Latin, dealing with the life of George Washington and other harmless topics. The writer, however, has never been able to share those fears. His general impression respecting the classical authors, which seemed to be that of his fellow students, was that those writers prepared their works chiefly to provide sentences with which Zumpt and Kühner might illustrate the perplexities of syntax and prosody.

KELVIN IN THE SIXTIES[1]

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THERE is the stereotyped teacher—the teacher who is like a collection of phonograph records which the human phonograph rolls out before his class in the same order annually—the talking text-book, who instructs his students what it will pay them to read, payment being made in examination marks—the type of teacher whose students, machine-made like himself, will grind out the tune, after the clockwork has been wound up, by due preparation on the candidates' part, the tune required written out by the examiner, and the clockwork started.

And, on the other hand, there is the great teacher, the inspired teacher, he who soars above scientific fashion, whose doxy becomes scientific orthodoxy, who produces thinkers, not mere successful examinees. Such was William Thomson, who became Lord Kelvin.

In the sixties, after the British Association Committee on Standards of Electrical Resistance had been started, but was still in its infancy, I had the rare good fortune to be one of Thomson's students. I, therefore, add to the many memoirs that have recently appeared a loving tribute from one who was at the Glasgow University when the quadrant-electrometer, the syphon recorder, the mouse mill influence machine, and many other instruments that have attained world-wide renown were being developed. Even after his severe illness in 1905 he never lost his keen interest in science, but at the time I am referring to he was not only a giant mentally, but of extraordinary physical activity.

When he came into his class-room, a room festooned with wires and spiral springs hanging from the ceiling like the rigging of a ship, he had hardly given a thought to what he was going to talk about—if it were Monday morning he had just returned from staying the week-end with Tait at Edinburgh, and he gave us an enthusiastic account of their talk, bubbled over with what they had been doing, was full of suggestions about it, told us how the manuscript of "Natural Philosophy" was progressing. We felt that we also had been discussing these points with Tait in his Edinburgh study, and listened with rapt attention to Thomson's narrative.

At that time the advanced proofs of only a fragment of that book had been printed off for the class. We saw the book grow, we felt pride in its growth, we almost felt that we were helping that growth.

[1] From the Engineering Supplement of the London *Times*.

That book by "T and T'," as is well known, consists of chapters which are more original than the papers usually read before scientific societies. Only one volume has ever appeared—the second, alas! alas! never will now.

To test the power of the Clarendon Press to publish such a book, Tait and he wrote down at random complicated equations, lines of wholly unintelligible reasoning, and then thought it would be a good joke to send out the proofs—as copies of an original paper—to various of their friends. And one day Thomson told me with a twinkle in his eye, "Nobody has yet found any mistakes in that paper."

Every morning, except Mondays and Saturdays, Thomson lectured twice; the first lecture, 9 to 10, was on experimental physics; the second, 11 to 12, on mathematical physics.

Electricity was the subject of the 9 to 10 lecture during a particular session which I have in my mind. But the experiments generally went wrong, and Thomson used modestly to say, "Faraday's result was so and so; mine is just the opposite. But Faraday, with inferior apparatus, *divined* the truth. Remember his result, not what you have just seen me obtain."

Thomson with all his genius, all his power of advising how an experiment should be made, with all his creative originality in suggesting the details of scientific apparatus and methods, could not make the experiments with his own hands. We all dreaded his touching the apparatus which we had set up and adjusted. He was too impulsive, too full of exuberant energy. After the apparatus was broken when he had touched it he was profoundly sorry. At that time it gave us the feeling that we were able to help him by trying experiments on his behalf. But this feeling resembled that of the calculator who helped Newton when he became too excited to finish the application of his principles to the explanation of Kepler's laws, or the feelings of the sculptor's assistant who transfers to marble his master's inspired creation in clay. We loved him the more that he allowed us to take a part—we felt that we were the soldiers of a great warrior.

In his mathematical physics lectures—aye, even in his elementary lectures—the suggestions that he poured forth were much above the heads of the ordinary undergraduates—over 100 in this class—and they gained little by coming to them except a register of their attendance, necessary for their degrees. For, as soon as he turned round to write on the blackboard, the students row by row began to creep out of the lecture room through a back door behind the benches and steal down-stairs, their bodily presence following their mental presence, which had left as soon as the reading of the roll-call was finished. From time to time Thomson put up his eye-glass, peered at the growing empty space, and remarked on the curious gradual diminution of *density* in the upper part of the lecture room.

This class consisted mainly of divinity, medical and law students, who, of course, should have been taught the elements of natural philosophy by some assistant provided by the university. To waste the time, energy and extraordinary original power of a genius like Thomson on such teaching was like using a razor to chop firewood. The junior clerks in Downing Street require instruction, but the prime minister is not expected to personally hold daily classes for them. And yet, during the past eighty years, there have been many prime ministers, but only one William Thomson.

But to those, like myself, who, after receiving some scientific training, had come from other countries to hear Thomson's talks, his suggestions, his buoyancy, were like the rays of brilliant May sunshine following April showers. The ideas of those students sprouted as never had they done before. The more thoughful gazed with eyes of wonder at Thomson developing an original paper during a lecture on anything that he might be talking about, we knowing that any notes or calculations that he might previously have made were on the back of some old envelope and left probably with his great-coat in the hall. "If you want to know what's in books go and read them for yourselves. I am telling you what is *not* in books," he used to remark at those lectures at the old University of Glasgow (now a railway goods station), the "Academia Glasgnana," founded by a bull of Pope Nicholas V., and built on the east side of the High Street in 1450 under the authority of Gulielmus Turnbull, Bishop of Glasgow.

The present university did not exist in my student days; in fact the classic stream Kelvin, although beginning to show signs of the drainage from manufactories spreading to the northwest of the city, flowed through a park and a dale still of a sufficiently sylvan character to make the words of the old song, "Oh! let us haste to Kelvin grove," not absolutely inapplicable.

To my question, "What books on electricity shall I read?" he replied "None! there are none. But you might read some of my papers in the *Philosophical Magazine*." Clerk Maxwell's classical treatise, Fleeming Jenkin's "Electricity and Magnetism," and the reprint of Thomson's own papers did not appear until some years afterwards. Fleeming Jenkin, who with Cromwell Varley became a partner in that famous firm of consulting telegraph engineers, "Thomson, Varley and Jenkin," was the first person to write a text-book which brought together disconnected and disjointed experiments and gave the elementary mathematical theory underlying them. In the preface of this book, which first appeared in 1873, the author said:

> In England at the present time it may almost be said there are two sciences of electricity—one that is taught in the ordinary text-books, and the other a sort of floating science known more or less perfectly to practical electricians and expressed in a fragmentary manner in papers by Faraday, Thomson, Max-

well, Joule, Siemens, Matthiessen, Clark, Varley, Culley and others. The science of the schools is so dissimilar from that of the practical electrician that it has been quite impossible to give students any sufficient, or even approximately sufficient, text-book. . . . A student might have mastered Delarive's large and valuable treatise, and yet feel as if in an unknown country and listening to an unknown tongue in the company of practical men. It is also not a little curious that the science known to the practical men was, so to speak, far more scientific than the science of the text-books.

Among Thomson's early discoveries was the fact that it was good for students to do laboratory work. So almost immediately he was appointed the professor of physics, at Glasgow, in 1846, at the age of twenty-two, he "organized a laboratory corps from volunteer students," and about 1849 he "established an incipient laboratory in the wine cellar of an old professor's house," so his successor, Professor A. Gray, tells me. In my time Thomson's laboratory consisted of one room and the adjoining coal cellar, the latter being the birthplace of the syphon-recorder. To avoid friction with the capillary glass syphon, which was moved to the right or left by the electric signals coming through the submarine cable, the end of the syphon was not allowed to touch the strip of paper, but a continuous stream of ink spurted out of the syphon on to this paper in consequence of the reservoir of ink, into which the other end of the syphon dipped, being kept highly electrified.

To find out what sort of electrical machine should be used for this purpose Thomson suggested that we should measure the efficiency of frictional electric machines. We did so, and brought him the result —viz., efficiency equals some small fraction of unity. He replied, "I can not degrade a man by asking him to use his energy so wastefully; I must design something better." And he did—viz., the influence machine; then when, by carrying out his suggestions, a fellow student and I had constructed an influence machine and got it to work, he sent us to the Glasgow Patent Office to see whether any one had thought of that principle before. And we found Varley's and other anticipations, with, however, this difference—that the earlier patentees proposed giving to the arrangement an initial charge to start its action, whereas Thomson's was a machine that worked on the compound interest law, starting with an infinitely small initial capital. This led not only to the "mouse mill" and the "replenisher," but to the class working all kinds of problems on investments at compound interest. "Now, suppose the interest is one one-thousandth per cent., paid every one one-hundredth of a second, etc.," and we who had never invested any money in our lives, indeed, possessed no money to invest, might have been mistaken for budding pupils of a stock broker had any visitor chanced to come into the lecture room.

There was no special apparatus for students' use in the laboratory,

no contrivances such as would to-day be found in any polytechnic, no laboratory course, no special hours for the students to attend, no assistants to supervise or explain, no marks given for laboratory work, no workshop and even no fee to be paid. But the six or eight students who worked in that laboratory felt that the *entrée* was a great privilege. College laboratories for any branch of physics did not, as far as I remember, exist anywhere in London during my student days. Principal Carey Foster started one in 1866 shortly after his appointment as professor of physics at University College, since he realized that making experiments was as great a necessity for students of physics as for students of chemistry. And it was Carey Foster's pioneering efforts to have a students' physical laboratory at University College, and his description of what Thomson had done at Glasgow, which made my mouth water and turned my attention northwards. Of course, the accommodation in Gower Street for physical work in 1866 did not differ much from what had existed at Glasgow since 1846, and certainly even in 1879, thirteen years later, Professor Cornu's students at the Ecole Polytechnique, Paris, never touched a piece of physical apparatus, although the *cabinet de physique* there contained all the originals of Regnault's classical apparatus, or facsimiles of the apparatus that Regnault had used in his investigations.

Thomson's students experimented in his one room and the adjoining coal cellar, in spite of the atmosphere of coal dust, which settled on everything, produced by a boy coming periodically to shovel up coal for the fires. If for some test a student wanted a resistance coil, or a Wheatstone's bridge, he had to find some wire, wind the coil, and adjust it for himself.

It is difficult to make the electrical student of to-day realize what were the difficulties, but what also were the splendid compensating advantages of the electrical students under Thomson in the sixties. We were like a band of emigrants following our leader in wagons across the prairies and the Rockies on the way into California in 1848. While his far greater genius, perseverance, and endurance would enable him to find nuggets, we perhaps might find specks of scientific gold. We were proud to follow him, we did not expect or even know what the laboratory luxuries of to-day would be, we did not need an Empire State Express train to hurry us in Pullman cars along a line of smooth level rails.

If the instrument given us by Thomson to work with had never been described to us—if its theory or even its use was entirely unknown to us—well, there were no maps for the early emigrants going westward to fall back on, they had to ford the streams for themselves, and did not expect to find bridges already built to enable them to step over every difficulty.

The fact that the students of to-day have such a wealth of apparatus at their hands, printed instructions supplied them, text-books galore, has made them globe-trotters in the region of science. They lack the self-reliance, the initiative to devise expedients for accomplishing ends which the emigrant pioneers in science fifty years ago had to employ. Indeed, it is becoming a question whether using a dictionary to translate a Latin or Greek play is not a better training for the inquiring faculty than working in a modern physical laboratory, since at any rate the translator has to use some thought.

Thomson openly expressed his contempt for a university that spent its time merely in holding examinations, as did the Burlington House University of London at that time. One day I was in his lecture room puzzling over an examination paper that he had set, when he advised me to take the paper home to my lodgings, as I should be much more comfortable there. Such a permission was an upheaval of all my ideas about scholarship examinations; so, boy like, I asked him how he would know that I should not look at books. But he only replied, "When you bring me your answers to-morrow I shall know what you have got out of books." I expect he sent me to my lodgings partly to impress on me the important lesson that all the books that exist will not solve a new problem.

The incident left a deep, lasting impression on me, partly because at the public announcement of the examination results he referred to his method, and jokingly ended with the remark: "This course was on hydrodynamics, and when we got into deep water there was only one student who was still in his depth." What a young engineer can do, using all existing knowledge, is, of course, what an examiner should try to test, *not* what the examinee can remember and reproduce.

He had great belief that one of the main uses of a university was to form character. He, Rankine, Tait and some other professors had a long discussion in his house one evening after dinner. Would he have been justified in asking that the student who had that day thrown a paper dart at the blackboard when he himself was writing on it should declare himself. Thomson thought no! As a matter of fact the student owned up. He was asked to absent himself from the class, but, on the other students pointing out that he would lose his degree by not attending, Thomson readmitted him.

Thomson always began his nine-o'clock lecture by devoutly repeating the General Confession from the Church of England Morning Service. I do not know whether the other Glasgow professors did. There was never the slightest interruption; the Scotch student is naturally reverent, besides, the prayer was said by Thomson with such fervor and impressiveness that the most stanch freethinker, the most frisky dart-thrower, could not but respect the convictions of the teacher

whom they all loved and honored. They might not be able to follow the lecture; but the affecting appeal which preceded it touched their hearts.

When he described to us how Joule in 1840 had experimentally proved that the rate of production of heat was directly proportional to the *square* of the electric current, and not to the first power, he used to add, "And Joule had the honor to have his paper rejected by the Royal Society. For it *was* an honor in those days." The rejection of the results of experimental work, although scrupulously accurate, because the experimenter was not already well known, filled Thomson with indignation. For example, the assertion of Sir William Snow Harris (*Phil. Trans.*, Roy. Soc., 1834, p. 225) that the heating power of electricity was *simply* as the charge, as well as many other electrical errors which Thomson used to dilate on, was held up to scorn before the class as "fashion *versus* truth in science." In the *Philosophical Magazine* for 1851 Thomson published an article explaining and defending Joule's work on the heating of conductors.

This ability to sift the wheat from the chaff, the courage to champion what he believed to be true, even if it were not the fashion, and the readiness to give up a theory when speculation lacked accurate experimental corroboration were marked features in Thomson's character.

During the sixties the world was very much interested in the possibility of an Atlantic cable. The 1857 cable had broken while being laid; the 1858 one had failed after one short month of existence; the 1865 cable snapped after 1,186 miles had been laid, and, although nine days were spent in trying to pick it up, and, although it was grappled many times, the rope broke; and this cable, like its predecessors, had to be abandoned. A few yards of this 1865 cable that had been picked up lay on the floor of the Glasgow laboratory and was often pointed to by Thomson as being what had given them heart and kept off despair. Then a prize of over three quarters of a million sterling was offered to the Telegraph Construction and Maintenance Company if they could complete the 1865 cable and lay an 1866 one. And they won it.

While it was remaining doubtful whether the two sides of the Atlantic would ever be coupled electrically, Thomson's secretary not unfrequently used to be sent to the Glasgow railway station a few minutes before the mail train started with this urgent message from Thomson: "I have gone to White's to hurry on an instrument. The London mail train must on no account start to-night until I come." And such was the national importance of the problem, and such the honor in which Thomson was held, that the station-master obeyed.

Many have used a Thomson's reflecting galvanometer and have

regarded it merely as an extremely sensitive galvanometer without knowing how it came into existence. It was devised by Thomson to enable him to utilize his mathematical solution of signaling through a long submarine cable, and was regarded of such national importance that a private act of Parliament was sanctioned by the Privy Council to extend the normal life of fourteen years for the patent of this cable "speaking instrument," as it was originally called. The invention of this instrument marks the theoretical solution of a most important problem, which solution Thomson found great difficulty in getting the electrician of that day to accept.

As early as 1855—before any long submarine cable had been constructed—Thomson published in the *Proceedings of the Royal Society* the theory of the propagation of signals through a cable based on a correspondence which he had had with the late Sir Gabriel Stokes, and he showed that the book "Fourier de la Chaleur"—that "mathematical poem," as he used to call it—contained, in Fourier's mathematical equations of the flow of heat, the entire mathematical solution of the propagation of electric waves through a cable. From "Fourier's series" he deduced that, whereas on a short overhead telegraph line the signal reaches its full strength at the distant end practically as soon as the signaler at the near end of the line begins to send it, with a submarine cable it is retarded, spreads out, and blurs the next signal. There is a past history effect as in politics and in many natural phenomena. The passing of an act of Parliament can not suddenly change a people; indeed, it is well known that the actual effect of an act of Parliament promoted by well-wishers is often gradually found to be most harmful, and has to be repealed or curbed in its action.

Herbert Spencer in his "Sociology" strongly advocated legislators to study the science of politics. Thomson would perhaps have said, "Study Fourier's mathematical poem."

If it were attempted to send a series of electric signals through an Atlantic cable with the *same* apparatus and at the *same* speed as messages are sent between London and Brighton, the signaler at the far end would not have the slightest knowledge that the signaler at this end was trying to send a message, whatever were the strength of the current sent into the cable. To work a long submarine cable, either time must be allowed for each signal to grow at the distant end, or, as this would make the sending of messages very slow, the receiving instrument and the signaler receiving the message must, like a clever doctor diagnosing a disease, be able to interpret mere indications. Sending the letter "e," for example, produces at the other end of a long cable a totally different result, depending on what has preceded it. In no case, at a speed of, say, thirty words a minute with a 3,000-mile cable, will it be more than a suggestion, even at the beginning of a

word; but in the syllable "toe" the "e" is as indistinct as the hurriedly written scrawl that you are very glad to get some one else to read for you.

Thomson wanted a receiving instrument which, unlike the ordinary telegraph instruments used in post-offices and railway stations, could render the interpretation of such suggestions possible in the hands of an expert signaler, and he devised the mirror galvanometer speaking instrument to obtain this result.

Another most important fact that his theoretical investigation brought out was that no increase of battery power could counteract the retardation in the signals produced by an impurity existing in the copper conductor of a cable, and hence that every yard of copper wire used in the thousands of miles of a long cable must be electrically tested for resistance before being used.

But all this appeared to the electrician as arising from the ignorance of an inexperienced young man who had never erected a mile of telegraph line in his life, and would not have been given a job in any telegraph office. And so when signals through the 1858 Atlantic cable became weak, and a message from the president to our queen took thirty hours in transmission, although containing only 150 words, and which would need only three or four minutes to transmit through any one of the good Atlantic cables of to-day, the only remedy of those who looked down on the theories of the young Glasgow professor was to use Whitehouse's "thunder pump," a magneto-electric machine which produced a sudden large electromotive force when the armature of the permanent magnet was jerked off the poles of the magnet. But these shocks only sent sparks through the gutta-percha insulating coating and hurried the poor cable to its doom, so that even the three words per minute which would have been the utmost limit of speed possible had this cable been entirely uninjured, were replaced by absolute silence.

But Thomson energetically struggled on and, pursuing (as he told me afterwards) a "Parnell-Biggar policy" at the board meetings of the Atlantic Cable Company, obstructed all business until the directors promised to have all the copper wire tested for resistance before being made into cable; and thanks to Thomson for his theory of signaling, to that engineer of energy and surprising resource, even when quite a lad, Sir Charles Bright, to Captain Anderson of the *Great Eastern*, and to all those who have followed in the history of submarine cable development the London Stock Exchange is by cable to-day within thirty seconds of Wall Street.

Thomson's work in connection with submarine telegraphy has been epoch-making. But thirty-three years ago it was associated with what I felt was a national loss. I give it in an extract from a long letter

which he wrote to me in Japan, December, 1874: "My dear Ayrton—You will be very sorry to learn of the terrible loss which has befallen us in the loss of *La Plata,* cable ship, with my nephew David King on board. . . ." David King and I had worked together for Thomson. I had seen them much in company with one another. In appearance, independence of thought, and in many ways there was great resemblance between uncle and nephew, so that I used to hope that a corner of the mantle of William Thomson might rest on David King.

Thomson has been called an engineer. In creative power, yes—a great engineer. But not in the forties, nay, even in the sixties, could a university student at either London, Glasgow or Cambridge learn what to-day is called even college engineering. Thomson had never learned to make a working drawing; he designed in metal. We students could not help him with the T square and drawing-board as we might have done had we received the college engineering training of to-day. He thought of a new instrument, a new method of accomplishing some result flashed on him, and he sketched in his pocket-book a rough indication of what he wanted constructed; I took the idea, or what I understood of it, in my head to Messrs. White, so it was not to be wondered at that alteration after alteration was necessary before the thing that was in Thomson's mind's-eye became realized in metal.

But oh! the delight of those days! Would we have exchanged them, had the choice been given us, for days passed in the most perfectly designed laboratory of the twentieth century without him? No! for the inspiration of our lives would have been wanting. As pathetically said, since his death, in the *Electrical Review,* "Le roi est mort," but we can not add, "Vive le roi," for were the whole world summoned, "no successor would there be."

MAN'S EDUCATIONAL RECONSTRUCTION OF NATURE

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THE purpose of education among those animals that train their young is adaptation to environment. Man's endeavor is the same, but with the growth of human society and of knowledge his environment has profoundly altered, a fact that education has only partially recognized, and this alteration has made it necessary to reinterpret adaptation. Among the lower animals, nature secures the necessary results mainly through instinct.

Jennings found[1] that paramecia collect around a mass of bacteria, pushing and crowding one another in apparent effort to reach the food, and Binet,[2] in one of those delightful, imaginative flights in which even the scientific mind at times is wont to recreate, would have us believe that most, if not all of the higher intellectual processes, including choice and volition, form part of the mental life of micro-organisms. But we are clearly drawing inferences beyond our right if we assume that action here has any other cause than the necessity which selection has made the conditions of survival. These organisms must do certain things and do them *always,* under penalty of extinction, and perhaps this is the reason why these same paramecia begin to gather around innutritious substances quite as surely as around nutritious. The attraction which a dilute solution of carbon dioxide has for them would then, as Jennings has suggested, be due to the fact that this product of organic waste is found wherever paramecia assemble; therefore, as they gather more often than otherwise around food and natural selection demands that they lose no chance of finding nutriment, carbon dioxide becomes a blind call to food. Instinct is thus organic behavior originating in the necessity of adaptation and directed in its course through the exigencies of the environment by natural selection. Whitman[3] has observed that our fresh-water salamander, *Necturus,* reacts to any object quietly introduced into the water, as though it were food. If so small an object as a needle, he says, be brought into contact with the surface of the water, *Necturus* instantly turns toward it. The reason is that the animal receives exactly the same stimuli from a foreign object that touches or passes through the water as it does from

[1] "Psychology of a Protozoan," *Am. Jour. of Psychology,* Vol. X., 1899, p. 503.

[2] Binet, "The Psychic Life of Micro-organisms," 1899, p. 61.

[3] "Biological Lectures from the Marine Laboratory at Woods Hole, Massachusetts," 1898, p. 303.

that which serves as food. In other words the animal responds primarily to water undulations, regardless of their cause, because it is through such undulations that it receives notice of the presence of food. In its most typical form instinct is thus seen to be chiefly a matter of animal organization, and the response to stimuli to be largely mechanical. This makes stable conditions necessary if it is to meet educational needs. But even here there is a little variation in the manner of reaction. *Necturus* has learned to discriminate somewhat between experiences, for, according to Whitman, "there is unmistakably a power of inhibition strong enough to counteract the strongest motive to act—the hunger of a starving animal in the presence of food."[4] But such limited power of reaction does not go far, and it will meet the needs of animals only so long as their life is of the simplest sort. They are probably capable of few adaptations, and these must be made at an enormous cost of time and life. But as life becomes more complex and less regular these instinctive responses do not answer. Animals must now learn to remember, and their actions must be guided by past experiences of threatening disaster, else they can not survive in the struggle.

Not many experiments have been made on the educability of animals low in the scale, but fishes have been taught to refrain from attacking minnows that are their usual food, by separating them with a glass partition extending across the aquarium until the larger fishes learn by repeated bumps on the nose that the little ones are not to be eaten.[5] Thorndike[6] has shown also that the minnow, *Fundulus*, can learn to find its way through a series of three partitions, each with an opening so located as to make the journey circuitous, and that it gradually improves on its previous record by eliminating blunders until finally it learns to go directly to each opening. While we do not know much about the mental processes here, it grows increasingly harder to explain action solely by the neural mechanism. Experience is evidently taking a more active part in the animal's life. The nervous system is becoming more flexible, more adaptable.

Recent observation has somewhat modified our views regarding action among lower animals. Jennings's studies[7] indicate that the method of trial and error is common even in one-celled organisms. This method, wherever found, unquestionably involves in some degree the utilization of experience. Such creatures can no longer be considered as merely reflex organisms in the presence of new needs and

[4] *Loc. cit.*, p. 305.

[5] See statement of Moebius's experiment in Darwin's "Descent of Man," second edition, p. 76, and Triplett's "The Educability of the Perch," *Am. Journal of Psychology*, Vol. 12, p. 354.

[6] *Am. Naturalist*, Vol. 33, p. 923.

[7] "Contributions to the Study of the Behavior of Lower Organisms," p. 237; Carnegie Institution, Washington, 1904. "Behavior of Lower Organisms," 1906.

difficulties, or, if we still designate their action in this way, the interpretation of "reflex" must be profoundly altered. Throughout the animal series improvement in the reaction to environment seems to signify greater nervous flexibility in dealing with experience rather than a complete change of method. In their fascinating paper[8] on the habits of solitary wasps, the Peckhams tell of one who in filling up her nest "put her head down into it and bit away the loose earth from the sides, letting it fall to the bottom of the burrow, and then, after a quantity had accumulated, jammed it down with her head. She then brought earth from the outside and passed it in, afterwards biting more from the sides. When, at last, the filling was level with the ground, she brought a quantity of fine grains of dirt to the spot and, picking up a small pebble with her mandibles, used it as a hammer, pounding them down with rapid strokes, thus making this spot as hard and firm as the surrounding surface." Soon "she had dropped her stone and was bringing more earth,"[9] when she again picked up the pebble and pounded that which was brought until all was hard.

The power to inhibit, so that the same action does not always follow the same stimulus under the same circumstances, which was observed in *Necturus,* indicates, perhaps, the first break in the mechanism of primitive instincts. The part that experience plays in the animal's life is becoming more immediate and direct. Just how much consciousness is involved in this, or, indeed, whether there is any, we do not know. Investigation has shown[10] that in man consciousness of means is not essential to the utilization of experience and there is certainly no reason for thinking it more necessary to the lower animals.

In the variability of instinct, also, we find mechanical organization less domineering, and in the study of wasps, to which we have just referred, the one preeminent, unmistakable and ever-present fact is variability. "Variability in every particular—in the shape of the nest and the manner of digging it, in the condition of the nest (whether closed or open) when left temporarily, in the method of stinging their prey, in the degree of malaxation, in the manner of carrying the victim, in the way of closing the nest, and last, and most important of all, in the condition produced in the victims of the stinging," some of them dying "long before the larva is ready to begin on them, while others live long past the time at which they would have been attacked and destroyed" had not the investigation "interfered

[8] "On the Instincts and Habits of the Solitary Wasps," by Geo. W. and Elizabeth G. Peckham, Wisconsin Geological and Natural History Survey, Bulletin No. 2, Scientific Series No. 1, Madison, Wis., 1898.

[9] *Loc. cit.*, pp. 22–23.

[10] Swift, "The Psychology of Learning," *Am. Jour. of Psychology*, Vol. 14, p. 217.

[11] *Loc. cit.*, p. 30.

with the natural course of events."[11] In this breaking away from the inherited way of doing things we seem to have a sort of organic initiative which, if we may not call it intelligence, must, after all, develop into it.

Observations on higher animals have been numerous, and Darwin quotes with approval a statement of Rengger that when he first gave eggs to his monkeys in Paraguay, "they smashed them, and thus lost much of their contents; afterwards they gently hit one end against some hard body, and picked off the bits of shell with their fingers."[12] Kinnaman,[13] in his extended study of the intelligence of two monkeys, found that they could learn to manipulate a complex series of locks and latches on a box, and that they made some progress in choosing better methods by eliminating useless acts and in making short cuts. He also tested men with the same apparatus and found that some were slower than the monkeys in finding how to open the box. While there was no evidence of ability to count, one of the monkeys could recognize position as far as three and the other as far as six.

All this is a clear advance on the mental processes of lower forms, which can not be explained solely by the mechanical response of a better organized nervous system. The change from the animal's customary behavior is too great and the variations too sudden for mechanical organization to account for them. And yet Kinnaman's report shows little method in it all. The monkeys knew enough to know when they had failed, which is more than can be said of the fishes until it has been battered into their nervous system through repeated blows on their heads, and they gradually improved on their method by making short cuts. But Thorndike's fishes also showed this improvement, though much more slowly. And this seems to mark an important difference in mental life. Monkeys do not need to wait until a certain mode of behavior has been worked into the mechanism of their organism by the operation of natural selection, as do paramecia, nor is it necessary that the external constraint, which encourages inhibition, be continued for so long a time as in the case of fishes. But, after all, the reasoning of monkeys seems to be of the same associative sort as that of fishes, and there is certainly no convincing evidence that they are able to get beyond this. Kinnaman thought that their action indicated generic images which enabled them to carry over something from a previous experience to a new situation, but we have already seen that even in man consciousness of the process is not necessary to the utilization of experience and it is difficult to see what a generic image of which we are unconscious could be. Indeed, on the theory of evolution, consciousness as an originating force in the learning process would seem to be much less necessary to the

[11] "Descent of Man," second edition, p. 78.

[12] *Am. Jour. of Psychology*, Vol. 13, pp. 98 and 173.

lower animals than to man, and the farther down the series we go the less important would it become, until, among micro-organisms, we can not speak of conscious adaptation without greatly overstepping the bounds of scientific accuracy. So far as the evidence goes, learning among the lower animals is strictly a matter of association. The more intelligent of them appreciate the failure of a method quicker than the others, and the discomfort resulting from it exerts a depressant effect upon the whole neuro-muscular system which tends to break up the incipient coordinations which were involved in the original action, and even to obliterate their neural effects. All this, of course, reacts against repetition. Success, on the other hand, is attended by a pleasurable feeling, and every one has observed the joyous look of animals capable of expressing their emotions, when they have accomplished what they have been trying to do. These pleasurable feelings increase the muscular tonicity which always tends to motor discharge, and this results in a partial reinervation of the coordinated group of muscles that were involved in the original movement. This naturally deepens the existing neural effect and tends to the repetition of the movement that occasioned it.

So far as our present state of knowledge permits us to draw conclusions, the intellectual difference between man and the lower animals consists primarily in just this differenec between associative reasoning on the one hand, and, on the other, inference in which the connection is obscured, by time or space, or by the complexity of the elements involved. And here, as before, the part that experience plays in determining action is the measure of intellect, only now its influence has been enormously multiplied. Articulate speech has enabled man to organize his experiences and transmit what he has learned, and it is not improbable that the higher psychical processes involved in reasoning owe to this human acquisition their development if not their origin. Speech has greatly accelerated adaptation—by no means an unimportant factor in the rapid changes of man's experience, since through it we learn from others that which may benefit or injure, and so avoid what might mean destruction of the species. And then, too, by enlarging the sum of the experiences it has greatly increased the facility in acquisition and assimilation which plays so important a rôle in human progress.

Learning in man, whether it be a new adaptation to a changed situation or the acceptance of an intellectual truth or moral principle, depends much upon the content of the individual mind, and this assumes infinitely greater importance in man than in the lower animals because of the immense complication of his environment. With animals this content embraces at most relation to the physical world and to other animals, but with man the physical world means and

includes much more. It grows until it embraces the universe, and the relation to others widens until, from a simple physical relation, it involves the action of men on the highest plane of consciousness. Education in man is to fit his offspring for all this—for the most perfect attainable life in this complicated and ever-growing physical and psychical environment. We have to educate for an essentially new universe and the demand for studies that will be directly useful in life, now becoming so energetic, while one strong expression of the growing consciousness of this need is yet an utterly inadequate expression of it.

Clearly, education through instinct, nature's way, becomes then wholly insufficient for man. Its method of adaptation is too slow when physical and psychical conditions change so rapidly. Besides, it costs enormously. The herring lays twenty thousand eggs, the oyster upwards of sixteen million, while the conger-eel requires the enormous number of fifteen million annually to save itself from annihilation.[14] Marshall and Brooks estimate that if you start with one oyster producing sixteen million eggs, half of which are females, and let them go on increasing at the same rate for five years, there would be oysters enough, if we estimate them as shells, to make a mass more than eight times the size of the earth.[15] As we descend the animal series these facts become still more startling. "Certain bacteria multiply so rapidly that the descendants of a single individual, if allowed to multiply unhindered for three days, would be represented by the figures 47,000,000,000,000."[16]

Among lower animals the individual is of little importance because infinite numbers can be produced, and the cost does not matter much, but in the human world the individual has become of supreme importance. It is costly to vitality to bring even one to maturity and expensive in every way to train him. Besides, the worth of a human being is recognized as permanent. A fine individual is of the highest value to the whole. The best are pioneers to a higher level. Fine individuals create a good society, and a superior society, in turn, is a prime factor in the production of the finest individuals.

With the lower animals the purpose is adaptation to environment, a strictly biological end, but the growth of knowledge and culture has introduced a higher element into human society which adaptation can not fully satisfy. This is that man must always improve his environment. Character is not merely a matter of heredity, but of heredity acted upon by environment. This is illustrated, on the one side, by the Juke family, and on the other by the transformation wrought in boys of

[14] C. J. Marshall, "Lectures on the Darwinian Theory," New York, 1900, p. 39.

[15] *Loc. cit.*, pp. 39–40; W. K. Brooks, "The Oyster," p. 50.

[16] H. W. Conn, "The Method of Evolution," p. 53.

criminal parents when placed in good surroundings. Many are convinced that the elimination of those in whom the anti-moral tendencies are strong is essential for moral evolution, and this is certainly nature's method, as she deals summarily with animals whose actions are at variance with the immediate good of the species. But human progress is not so simple, its problems are not so easy of solution. Discrimination is necessary in order to know what are the anti-moral proclivities. Seemingly reversionary tendencies in early life, for example, are not always bad, since many times they are the source of our best social strength and virtues. The so-called criminal instincts of children are survivals of acts that among primitive races fitted their possessors to survive. Deception and the strength and willingness to fight well, and to kill, were essential to racial existence, and these were the highest virtues of which primitive man could conceive. To-day these acts are wrong in adults because they are not only unnecessary, but hinder progress. They do not fit man's reconstructed nature. They are anti-social. Yet the elimination of boys with these anti-moral characteristics would be fatal. Altruism arose as a kind of enlarged egoism. At first man must have been chiefly, if not wholly, individualistic, but very soon a time came when individual selfishness no longer served its egoistic ends, and self preservation required the extension of each self to embrace all members of the tribe. Self interest thus became absorbed in tribal interest, not at first because of any moral ideas about the rights of others, but solely because in this way each one's self-interests were better served. But these primitive instincts are not without meaning for modern life. The readiness of civilized boys to fight shows an independent, active, aggressive character which, rightly guided, leads to manly courage. The determined opponent of civic corruption, the man whose onslaughts no threats can stay, was a boy who fought for boy's rights. The prevailing social ideas are important in giving these tendencies the direction that makes for progress, and their very persistence and vigor is a necessary element in evolution.

The power of ideas and actions when intelligently applied to conduct has been shown in the complete change of life of the New York City toughs who were given the ideals and ambitions of the George Junior Republic. In the slums of the city their racial tendencies followed the drift of excitement and adventure natural to a criminal environment, but with the social suggestions and inspirations of the republic these instincts found new outlets which led to manhood under civilization, while still satisfying the organic yearnings of the race. The evolutional impulse in all this is an atmosphere of moral thoughts and actions, but we must take care not to confuse mere custom or tradition with morality.

Animals are dependent upon conditions in the selection of which

they had no part. Theirs is merely to adapt. Man, on the other hand, may assist in bringing about conditions amid which the next generation will live. As adaptation is as much a human as an animal characteristic, the importance of the environment becomes evident, especially when we remember that in man no less than in the lower animals those qualities are selected for survival that best fit the conditions. Alfred Russel Wallace has given a splendld illustration of this in his "Malay Archipelago." He wrote:

> There are now nearly five hundred people in Dobbo, of various races, all met in this remote corner of the east, as they express it, "to look for their fortune," to get money any way they can. They are most of them people who have the very worst reputation for honesty, as well as every other form of morality—Chinese, Bugis, Ceramese, and half-caste Javanese, with a sprinkling of half-wild Papuans from Timor, Babber and other islands—yet all goes as yet very quietly. This motley, ignorant, blood-thirsty, thievish population live here without the shadow of a government, with no police, no court and no lawyers; yet they do not cut each other's throats, do not plunder each other night and day, do not fall into the anarchy such a state of things might be supposed to lead to. It is very extraordinary! . . . Trade is the magic that keeps all at peace and unites these discordant elements into a well-behaved community."

The power to modify environment gives man possibilities not possessed by any of the other animals, but it adds vastly to his social responsibility in education. The environment is put upon the lower animals as it were from overhead, and they are left no choice but adaptation or extinction, but man may make his own environment, and in this way break a trail for progress.

The difficulty in applying the principle of natural selection to education is that we do not intelligently determine who are the fittest. In nature the conditions demanding adaptation are comparatively simple and definite. This is true also of primitive man, and, indeed, quite largely of early civilized society. But the enormous enlargement of human interests dims our vision. In one respect the lower animals have the advantage of us in their instinctive educational methods. Their teachers are never troubled by doubts concerning the ability of their pupils. All receive equally careful training for life. They do not prejudice the future of any by an adverse verdict so early in life that the best in them may not yet have appeared. They train all in the best way for success, which in their case means survival, and then leave the final decision to natural selection. The conclusion of one of England's foremost statisticians that the senior wrangler has twenty-five times the innate ability of the lowest on the honor list, because in one year the former obtained 7,500 credits to 300 of the latter, is one of the humorous results of the so-called scientific method of investigation. Against the hallucination of such measurements let us remember that Darwin's father prognosticated that he would disgrace his family because he cared for nothing but shooting, rat-

[17] *Loc. cit.*, p. 443.

catching and dogs, that Harriet Martineau was a dull child, and Seward "too stupid to learn," that Isaac Newton at twelve led his class at the foot, that Samuel Johnson was lazy, Robert Fulton a dullard, Oliver Goldsmith insufferably dull in his teacher's opinion, Byron lowest in his studies, Richard Sheridan insignificant as his teacher saw him, John Hunter slow and late to learn, Linnæus, in view of his stupidity, recommended by his pedagogue to be a cobbler, and that Dean Swift through "dullness and insufficiency," and Goethe likewise from seeming inability, forfeited their degrees.

It is not to be forgotten that the survival of the fittest is always relative to the conditions demanding adaptation and, while animals have no preference, man may exercise a choice as to the conditions to which he will adapt himself, and this is broadly the distinctively human quality. The cleverest boys in the slums of New York become the most skillful thieves. In the George Junior Republic, as we have seen, the same boys grow into the best citizens. Here environment is created and chosen by society for the boys; where it appoints them to a slum environment it produces thieves and criminals; where it gives them a rational environment out of the same material it produces first-class types.

Now society may fail to choose for itself the highest goal, which is nothing but failure to select the largest environment to which to adapt itself. It has choice of various inferior lines of growth. Then "practical" education will aim to fit the individual for most perfect adaptation to the inferior plane chosen. *Man has largely inherited the animal method and only partly adopted the human.* Nature has provided education for animals only in a state of stability. For change, improvement, nature has provided animals with nothing that can be called a method, for the means it uses is destruction—destruction for all who do not conform to the needs of the change, and in working out a new adaptation, the destruction of all who stray extends over an immense period before a new state of stability is established with a new instinct to conserve it. Now this is an incredibly blundering and costly method where the individual is of any account and where the goal is of value, both of which conditions are true of man. It meets the need of animals because survival is the only thing aimed at and the "fittest" are those adapted to the prevailing conditions. The inadequacy of the principle for man and education becomes evident since the conditions demanding adaptation, if ethically low, will call for and bring out men of an inferior type and in a society of this kind the few that might seek to make their adaptation to a more universal environment, though they would be the best from the standpoint of civilization and progress, would be suppressed. But the society choosing this principle stagnates and, in the long run, retrogrades. Now the purpose of education should not be merely to fit each generation

for adaptation to the grade that society may happen to hold at that time, but to create in men the habit of discriminating and of choosing that which leads to something higher.

The importance of this point of view is not lessened even if it be shown that natural selection is not the only force operative in producing change. New characteristics may appear suddenly, so-called mutations, but their persistence is after all dependent upon the environment. True, they may persist without being of immediate advantage, but only when conditions are not too unfavorable. Here, again, it should be the purpose of an intelligently endowed society to make conditions that will preserve incipient and less stable individual variations that have appeared, according to the supposition, through no direct environmental influence, but which may tend toward a higher social organization. It is not enough that conditions permit the survival of such varieties under difficulties; they should favor their continuance. While some "mutations" may exist under conditions not altogether favorable, others will require social recognition and society should see to it that the persistence of such sensitive "mutations" is not too hazardous. In this way a tendency to vary, a characteristic which means much for progress, may be fostered. In his work with plants Vilmorin found, according to Darwin, that "when any particular variation is desired, the first step is to get the plant to vary in any manner whatever, and to go on selecting the most variable individuals, even though they vary in the wrong direction, for the fixed character of the species being once broken, the desired variation will sooner or later appear," and Burbank has recently made the same observation.

Among lower animals variation facilitates new adaptations, but in man it has assumed an added function, that of suggesting new departures, new lines of progress, and in doing this it makes important contributions to the growth of experience. Education is always in danger of arrest from compression by immediate or "practical" aims. It should be of a sort that admits of indefinite expansion so that in the end it may become commensurate with life; but this capacity for enlargement requires something more than knowledge. Inability to see this led to the fallacy of the educational system of the middle ages; and we have fallen heir to their infatuation for formal training and learning. Information did fairly well for the simple conditions of early times when the necessary adaptations of life were neither complicated nor numerous, but if education is to be adequate to the life of to-day it must take the whole plexus of social forces into account and these social forces are, after all, only biological principles working in human society, to be intelligently interpreted and used for the greater life of society.

One of the elements in progress, and by no means an unimportant

one, is that of which we have just been speaking, and which we may call suggestive variation. The world is moving with constantly accelerated velocity, not merely because we have more information to-day than yesterday, but because what we know means more to us, and this alchemistic power of getting out of facts something not superficially visible in them is mind's contribution to progress. Now education has never appreciated the importance of variation in human society and for that reason has never set itself to develop it. The very capacity for variation, implying as it does a certain flexibility, facilitates ready adaptation in the individual, and its suggestive influence on society promotes adaptation in others. The means, of course, by which this influence becomes effective is speaking and writing. The function of education here is to develop a mental attitude that is friendly to variation, and to train to rightly see and interpret relations. There seems to be an impression that if we just give a child or a man information enough he will at some time and in some way—though we are never told just when or how—learn to apply it to the problems of life. But the facts do not justify this view. The astonishing velocity with which science and industry are moving to-day calls for correspondingly rapid adjustment, and owing to defective principles of education we are unable to meet the demand. This is the reason for the conflict between labor and capital. Industry has advanced so fast that instinctive society could not keep up with it. Not educated to vary flexibly we can not adjust ourselves in time to new conditions. We are confused and baffled by them. The intellectual element enters into human adaptations, and the more rapid the change the more conscious and purposive must adjustment become. Fitting for this adjustment belongs peculiarly to education. But here we fail. We have given too narrow an interpretation to education. Our narrow theory regards it as a preparation to adapt ourselves to a certain set of conditions, *i. e., those found existing.* The result is intellectual rigidity and obstinate resistance to evolution. The mental processes, moulded in certain mechanical forms of activity, find hardship in readjustment when conditions change, and, as we have seen, change is the rule to-day. Here, again, we are adhering too closely to the animal method, where movement is slow and rapid adaptation is not expected. Education should seek to develop a mental plasticity, a capacity for understanding and getting control of new situations and for making them.

To-day the great changes are social. Evolutionary conditions are pressing us toward a fundamental reconstruction of society. The reconstruction is a profound social variation. Education—that is to say, those who have the magnificent educational equipment of the nation in charge—should have foreseen this and made the new generation of youths ready for it, should have prepared them to recognize

it as another great unfoldment of man, comprehending, assisting and developing it. But education has been engrossed in the comparatively petty rôle of teaching lessons. It has fitted children for immediate, *instinctive* environment, quite omitting rational, or higher social, environment. The result is present conditions—a practical deadlock of social forces. Education can not truly awaken the interest or command the confidence of the people until it assumes the higher function.

The present obstructors of social reconstruction or variation are the ill-educated though perhaps very much schooled. For schooling and education are not the same. The new social variation now beginning is an industrial readjustment which shall enable each individual, regardless of the accident of birth, to realize to their full value all of his native powers; and this will promote progress by removing artificial restrictions on individual variation. It would be very easy in this country, on the basis of accepted American principles, to effect the transition if educators, whose business is moulding minds to grasp the larger aspect of things and training them in the power to alter their views instead of reposing in fixed ones, had done their work. The current method is to impede social transitions; the intelligent course is to facilitate them. When educators rise above mere schoolmastering, social deadlocks and cataclysms will be of the past. The changes they involve will be welcomed.

While, therefore, the animal method of education is for static life—stability, with man it must be for dynamic life—change, improvement. And yet man's course in the past has not been complimentary to his intelligence, since many, if not most of his important alterations for the better have not been made by intelligent choice of the change itself, nor by choice of the best way; rather he has resisted as long as possible, until life became so bad that nature by some kind of punishment or eruption forced improvement upon him, as she does upon animals, by her power of destruction. This is the principle of revolutions. Sometimes they succeed in raising society to the level of the few higher individuals, but often they are suppressed by the forces in resistance to variation and adaptation.

This adaptation to a large nature brings with it a complete mental reorganization. Nor, indeed, is this lacking in physical confirmation. We can already trace certain corresponding physical changes in the constitution of the brain—the increase in association fibers in certain parts of the cortex shortly after eighteen years of age, indicated by Kaes's investigations, and the extension of Flechsig's association-centers in higher animals and particularly in man. Some of these cerebral changes seem to occur when increasing complexities of life are making new demands on intelligence.

Recent studies[18] suggesting that the human brain has not increased in average size for 20,000 years or more, also point to improvement in cerebral organization as the distinctive feature of the civilized brain. Further, both Kaes and Vulpius have shown that there are additions to the association fibers in parts of the brain long after thirty-eight years of age.

Every age brings its change of view. Acts that were once considered the most virtuous are to-day abominable. Why did not the people of past ages see at least some of these things as we do and know that they were wrong? What will future generations say of us in this respect? Are we never to reach a stage of culture that will enable us to think out these questions experimentally and intellectually, so that we may jump the trying experience of intervening ages? Are we never to eliminate dark ages? The processes of human progress are extremely crude. They are simply naturalistic. Now one of the ultimate functions of education, considered in the large, is to develop a science of progress. The naturalistic way is too expensive.

We are comparing the animals with their instinctive view of nature in its simplicity—an inherited mode of behavior developed on the basis of narrow experience—with man's mode of action. Man has developed his larger view of nature as complex through a more varied experience, but he acts to-day preponderantly on the instinctive method of the animals. While he has acquired the use of reason this has been only grafted on to the instinctive method of reaction. The cause of man's tardiness in abandoning the instinctive and adopting the intelligent method is that science is of modern and comparatively recent growth, and it is science that has entirely changed our conception of things by giving us a new view of life in revealing more of the inner nature of the universe. This has made the simple animal view inadequate. Wireless telegraphy by which England and America converse with one another through space, the X-ray with which we see through matter, and radio-activity which has established the complexity of the atom, indicate the incredible revolution that is going on in the character and scope of man's universe. But the animal takes the simple, immediate, and direct view of the world. It assumes and accepts without question that it sees the whole thing in its simple perceptions, and man has hardly at all emancipated himself from this method of interpreting.

We have found ability to profit by experiences the test of survival among all animals. With organisms low in the scale this learning is not an individual matter, but belongs to the species and takes the form of adaptation, and the advantage is bought at an enormous cost of life. A little higher, and individuals break away somewhat from inherited modes of behavior and action begins to be influenced by past

[18] *Amer. Jour. of Insanity*, Vol. 58, p. 1.

experience. Soon this becomes common, and the animal may then properly be said to learn, though there is no evidence that at this stage utilization of experience is ever conscious. When consciousness once becomes a factor in determining action, capacity to profit by experience is a measure of intelligence, and it is just this increased sensitiveness to experience that gives the facility in adjustment of which we have been speaking. Intelligence restricts the action of natural selection by enlarging the individual's range of adaptation and by giving insight into conditions and the power to create new ones. There is greater latitude for variation without destruction, and variation, again, may suggest other lines of progress by means of which nature's selection may be guided, so that she may find those fittest who are most appreciative of the larger, more universal environment which it is education's privilege to conceive and foster.

THE PROGRESS OF SCIENCE

THE NOBEL PRIZE IN PHYSICS FOR 1907

THE award of the Nobel prize and the Copley medal to Dr. A. A. Michelson, professor of physics in the University of Chicago, is of interest to Americans from more view points than one. Naturally and properly, it gratifies their national pride. But more than this, it marks a widespread recognition of the development of pure science which has recently occurred in this country, and the partial attainment of those ideals advocated so vigorously by Rowland in his "Plea for Pure Science," addressed to the American Association for the Advancement of Science at its Minneapolis meeting. In the past these ideals have been typified by the work of Franklin, Henry, Gibbs and Rowland—honorable names—but separated by intervals all too long.

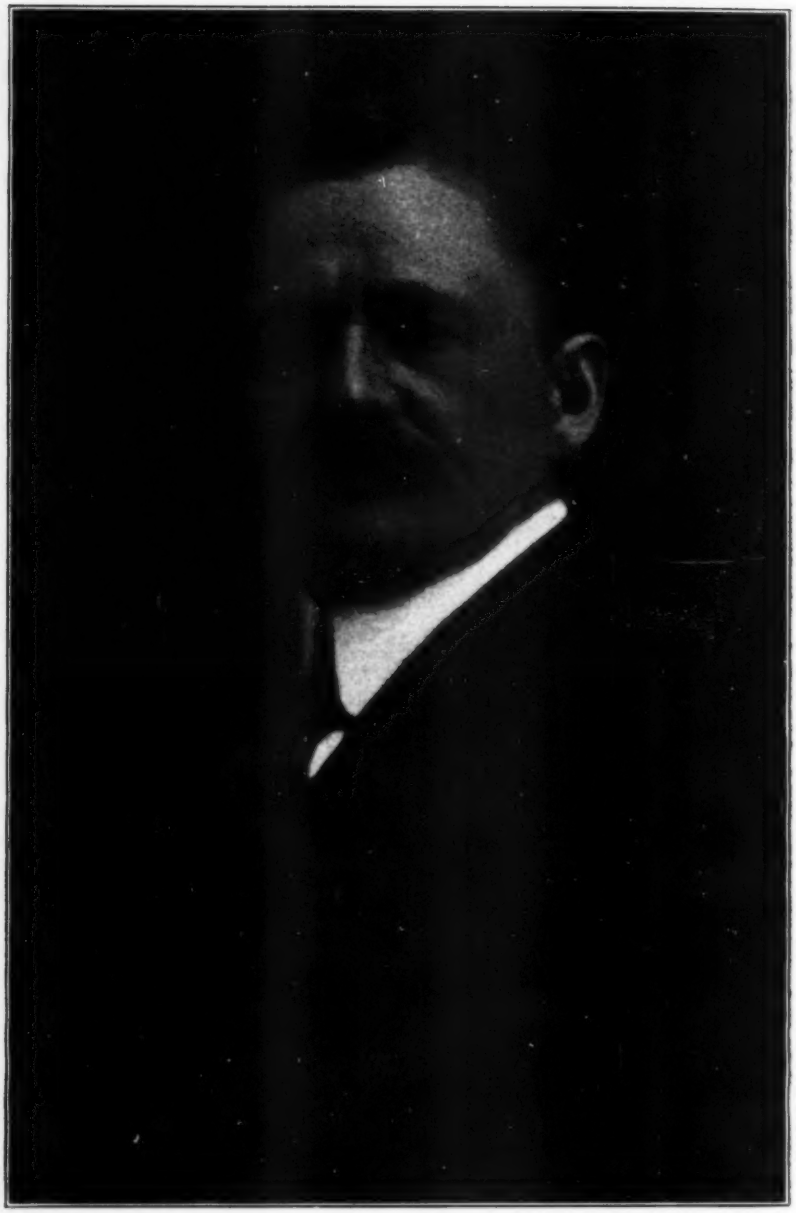
But most important of all is the encouragement which pure science is now receiving from various sources. For while all prizes and research funds combined can do little to kindle or encourage the spirit of investigation in the mature mind, they do elevate the position of the investigator and foster the ideals of pure science in such a way as to make a career of research more attractive to able and ambitious youth. Great things may be hoped for American science when once the trend of young talent has set less exclusively to commerce and engineering.

In the history of optics Professor Michelson's work is certain to form a large chapter. His highly accurate determination of the speed of light is already a classic. His interferometer, devised for the purpose of detecting relative motion between earth and ether, bids fair to become the standard instrument for the measurement of all minute distances. Few facts in contemporary science are, indeed, more striking than the quiet and modest, but effective, manner in which Michelson and Benoit have, by their determination of the standard meter in terms of the red cadmium wave-length, morally, though not legally, established the wave-length of light as the international standard of length.

Another means for dealing with quantities in the sixth and seventh decimal places is Michelson's *echelon* grating which is perhaps the most powerful spectroscopic device now available. The product of his new engine for ruling diffraction gratings is awaited with great interest especially by astrophysicists.

The superficial observer may be tempted to identify the work of Michelson with the accurate determination of certain numerical constants. A greater mistake could not be made. For in nearly every case these determinations have been made possible by the discovery of some important method or principle whose fruitfulness it is impossible as yet to estimate.

For forty years after its enunciation the principle of Avogadro remained practically unrecognized by chemists. Nor is this tardiness in the recognition of scientific values confined to scientific men. Faraday had both the dynamo and the electric motor in full operation in 1831; but these machines were not placed on the market until about 1876. We therefore attempt no accurate estimate of the achievements of Professor Michelson, but merely extend to him the congratulations which he has so richly earned.



PROFESSOR A. A. MICHELSON,
Head of the Department of Physics in the University of Chicago.

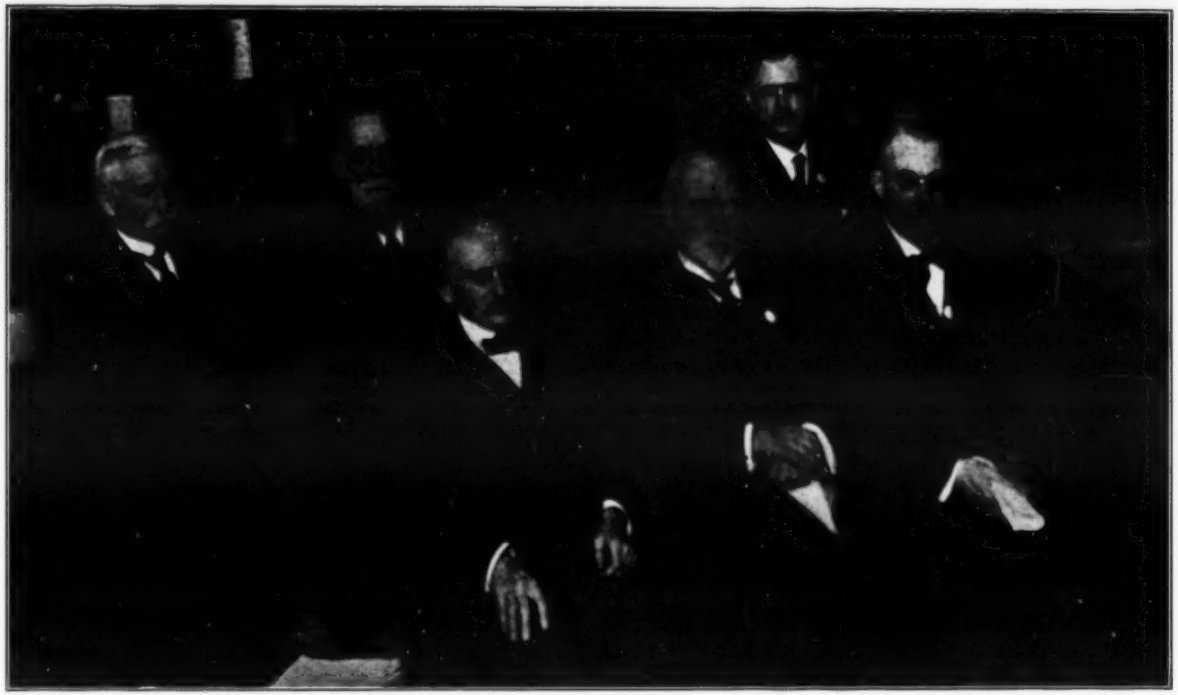
AMERICA'S CONTRIBUTIONS TO SCIENCE

THE award of one Nobel prize in science to a citizen of the United States, even though his birthplace was in Germany, is a recognition as great as this country may properly claim. Indeed, it seems that the award in physics should have been made to Kelvin, if the plan of conferring the prize for distinguished services were to be followed, rather than the original instructions of Nobel's will, which required that the prizes should be conferred on those who contributed most materially to benefit mankind during the year immediately preceding. On the other hand, if the prizes had been conferred in accordance with the terms of the will, for "the most important discovery or invention in the domain of physics" "contributing to the benefit of mankind, the prize should have been awarded first of all to Dr. A. Graham Bell and Mr. Thomas A. Edison. The awards in the sciences so far made have been:

	Physics	Chemistry	Medicine
1901	Röntgen	Van't Hoff	Behring
1902	Lorentz and Zeeman	Fischer	Ross
1903	Becquerel and M. and Mme Curie	Arrhenius	Finsen
1904	Rayleigh	Ramsay	Pavlov
1905	Lenard	von Baeyer	Koch
1906	J. J. Thomson	Moissan	Ramon y Cajal & Golgi
1907	Michelson	Buchner	Laveran

The national distribution is: Germany 7, England 4, France 3, Holland 2, Denmark 1, Sweden 1, Russia 1, America 1, Italy ½, Spain ½. It is certainly somewhat disquieting if one accept these figures as measuring the scientific productivity of this country as compared with others, and there is, as a matter of fact, some reason to fear that one out of twenty does not seriously misrepresent our proportion of eminent scientific men. In his widely-quoted Harvard address, Mr. Owen Wister allows us three of his forty-three immortals. If he will kindly permit us to amend his list by making the obvious substitution in philosophy of Professor James for Professor Cohen, and the addition of Professor Newcomb and Dr. Hill, as astronomers without peers, we should be allowed one eighth of the world's most eminent scholars, which is probably a larger proportion than we possess.

That we have not produced great men in proportion to our population and our wealth amply justifies the arraignment which Professor Webster prints in the present number of the MONTHLY It must, however, be remembered that in so far as scientific productivity is measured by the number of men of international eminence a country may possess, this would refer to the preceding rather than to the present generation. Most eminent men have done their great work at least thirty years ago, and it is perhaps not discouraging that the possibilities for scientific work in this country were small in the seventies as compared with the opportunities to-day. Whether we are now accomplishing research proportionate in importance to the numbers engaged in it and to the facilities given them is a different question and one which it is probably impossible to answer. It appears from various bibliographies that about one seventh of the titles are American. There are no grounds for assuming that their average value is either above or below that of those from other countries. It seems that we are clearly out-classed by Germany in the number and value of our scientific publications, that we stand pretty close to Great Britain and France, and that we are surely before any other nation. Then if we wish to take the patriotic and optimistic point of view, we can find comfort in the fact that no other nation has in the past twenty years enjoyed such a notable increase in scientific activity. Should this activity continue to increase at the same rate for the next twenty years, there will be no occasion to shun comparison with other nations.

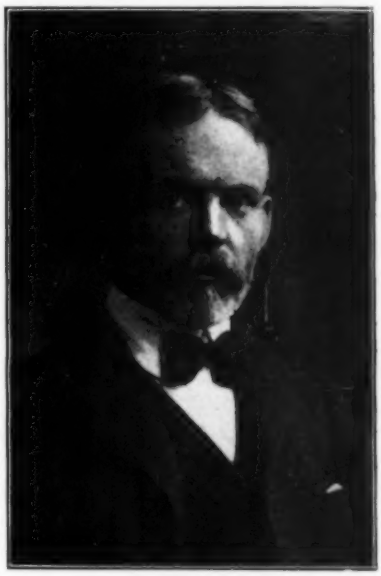


R. S. Woodward. C. M. Woodward. Edward W. Morley. John M. Coulter. Edward L. Nichols.

PROFESSOR LUDWIG HEKTOEN,
Vice-president for the Section of Physiology and Experimental Medicine.

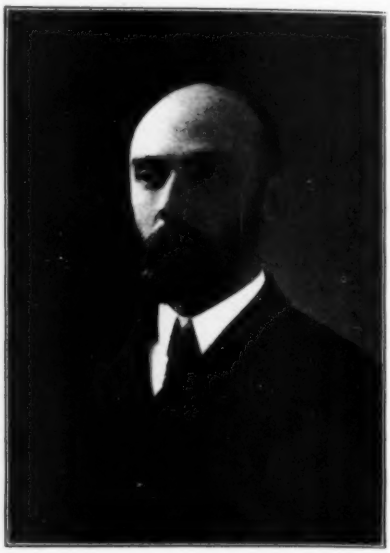
SCIENTIFIC MEN AT THE MEETINGS OF THE AMERICAN ASSOCIATION

IT is one of the pleasures of attending a large meeting of scientific men to see the leaders of science and to personify work with which we are familiar by associating it with the face and presence of its authors. A lesser but still legitimate satisfaction is found in seeing their portraits, and we have regarded it as desirable to present to readers of the MONTHLY photographs of the officers of the American Association with whom they would like to be acquainted. In the last issue of the MONTHLY there was a portrait of the president, Professor Chamberlin, who, like Professor Michelson, gives distinction to the University of Chicago, and deserves a second Nobel prize, were there one established in geology. We give now a plate showing five presidents of the association and the chairman of the local committee. On the right is the president of the Chicago meeting, Professor E. L. Nichols, of Cornell University, eminent for his work in optics and electricity and honored for his services to education and scientific organization. Next is Dr. W. H. Welch, of the Johns Hopkins University, the retiring president, the leader among our pathologists both in research and medical instruction. Adjacent is Dr. E. W. Morley, who has recently retired from his chair at the Western Reserve University, equally distinguished as a physicist and as a chemist, the recipient of the Davy medal from the Royal Society at the same time that Dr. Michelson received the Copley medal. To the left is Dr. R. S. Woodward, the author of valuable researches in mathematical physics, as president of the Carnegie Institution occupying the most important executive scientific position in the world. By him is Dr. C. M. Woodward, of Washington University, known both as an engineer and as a leader in educational work, especially in the introduction of manual training. The remaining portrait is of Dr. John M. Coulter, head of the Department of Botany at Chicago and one of those who have given the university in the



PROFESSOR E. B. WILSON,
Vice-president of the Section of Zoology.

PROFESSOR FRANZ BOAS,
Vice-president of the Section for Anthropology.



PROFESSOR HENRY P. TALBOT,
Vice-president of the Section of Chemistry.

few years of its history a position in scientific research rivaled only by Harvard and Columbia.

The four vice-presidents of the association whose portraits are given are Dr. Ludwig Hektoen, professor of pathology in the University of Chicago and director of the Memorial Institute for Infectious Diseases, known for his work in pathological anatomy and bacteriology; Dr. E. B. Wilson, professor of zoology in Columbia University, eminent for his contributions to cytology and experimental morphology; Dr. Franz Boas, of Columbia University, whose researches have given him the leading place among anthropologists in the country, and Dr. Henry P. Talbot, one of those who has made the Massachusetts Institute of Technology a great center for chemical research as well as instruction. When the American Association can secure officers such as those mentioned here, we can with satisfaction place our working men of science beside those of any other nation.

SCIENTIFIC ITEMS

WE regret to record the death of Mr. Morris K. Jesup, president of the American Museum of Natural History. By his will $1,000,000 is given to the museum. Professor Henry F. Osborn, curator of vertebrate paleontology and professor in Columbia University, has been elected president of the institution to succeed Mr. Jesup.

THE hundredth anniversary of the birth of Charles Darwin, which occurred on February 12, 1909, and the fiftieth anniversary of the publication of the origin of species, which occurred on November 24, 1859, will be celebrated by the American Association for the Advancement of Science at its Baltimore meeting a year hence. Cambridge University also proposes an adequate celebration.

PROFESSOR REGINALD W. BROCK, professor of geology in the School of Mining, Kingston, has been appointed director of the Geological Survey of Canada.—M. Bailloud, of the Toulouse Observatory, has been appointed director of the Paris Observatory.—M. Henri Becquerel has been elected president of the Paris Academy of Sciences, and is succeeded in the vice-presidency by M. Bouchard.